Thirty-Fifth Illinois Custom Spray Operators Training School

Summaries of Presentations
January 5 & 6, 1983
Urbana, Illinois
and
1983 Agricultural Pesticide Dealers and Applicators Handbook

Cooperative Extension Service
University of Illinois
at Urbana-Champaign
College of Agriculture
in Cooperation with
the Illinois Natural History Survey

This training school is presented specifically for commercial applicators of agricultural chemicals by the University of Illinois at Urbana-Champaign, College of Agriculture, Cooperative Extension Service, and Illinois Natural History Survey, but is open to all persons involved in the handling of agricultural chemicals. The school promotes the proper, timely, and wise use of agricultural chemicals. We gratefully acknowledge the assistance of the Illinois Department of Agriculture, the U.S. Department of Agriculture, the Illinois Agricultural Aviation Association, the Illinois Ground Sprayers Association, and the Illinois Fertilizer and Chemical Association in planning the program. Abstracts in this manual bring to you the latest research information, but do not constitute positive recommendations unless so stated. Statements made herein are the responsibility of either the speaker or the institution he represents. Reproduction and publication are permitted only with the approval of each author.

Many of the abstracts in this manual are research reports, and the chemicals listed are not registered for use by the public. Those listed in the official Circulars in the back of this booklet are officially registered for the suggested uses. Even in these instances, it is recognized that extreme variations in weather, cropping practices, fertilizer use, application techniques, use of other pesticides, and other factors may influence the effectiveness of the chemical. Adverse effects, such as poor results and plant damage, should always be reported to your county Extension adviser so that he may inform the interested people at the University of Illinois College of Agriculture and the Illinois Natural History Survey.

Many of the chemicals listed herein have common names which are used in preference to trade names. However, it is also possible that a chemical may only be known by its trade name. If there is more than one trademarked product for the same chemical, we ordinarily use the common chemical name, but occasionally through oversight an error may be made. If this has occurred, accept our apologies and call it to the attention of the author of the article.

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1984 Date for the
36th Custom Spray School
JANUARY 3, 4, 5, 1984

Thirty-Fifth Illinois Custom Spray Operators Training School

January 4, 5, and 6, 1983

Sponsors: Cooperative Extension Service, College of Agriculture, University of Illinois at Urbana-Champaign, Illinois Natural History Survey, Illinois Department of Agriculture, Illinois Agricultural Aviation Association, Illinois Ground Sprayers Association, and Illinois Fertilizer and Chemical Association

Registration:	January 4, Tuesday—8:00 a.m. to 9:00 p.m.,	Convention Center, Ramada Inn
	January 5, Wednesday—8:00 a.m. to 5:00 p.m.,	Illini Rooms-A,B,C,—Illini Union
	January 6, Thursday—8:00 a.m. to 12:30 p.m.,	Illini Rooms-A,B,C,—Illini Union

SPECIAL EVENTS, TUESDAY, JANUARY 4, 1983

1. *Illinois Ground Sprayers Association*

Convention Center, RAMADA INN—Brundage, Zuppke, and Illiniwek Rooms
Ben Kirk, presiding

10:00 a.m.	Welcoming Comments and Opening Remarks	
10:10	IFCA Report	D.M. Dunbar
10:25	So You're Handling Hazardous Materials	G. Baker
11:00	Illinois Department of Agriculture Report	T.A. Walker
11:30	Weed and Grass Control: How Are We Doing? What Can We Count On?	M.D. McGlamery
12:00	Lunch	
1:30	Drift: Are We Making Progress in Understanding, Evaluating, and Controlling It?	B.J. Butler, L.E. Bode

2. *Illinois Agricultural Aviation Association*

RAMADA INN—Alumni Room, Ken Degg, President, presiding

10:00 a.m.	Welcome and Comments	
10:10	Planning A Fly-In Clinic for 1983	L.E. Bode
10:40	1982 Accident and Incident Report	GADO 19

11:10	The Selection and Use of Computers in Your Business	D.E. Erickson
12:00	Lunch	
1:30	Aerial Application Category-Illinois Department of Agriculture Perspective	T.A. Walker
2:00	Business Meeting	

The Agricultural Aviation Association Meeting will adjourn after the business meeting.

3. Special Smoker

RAMADA INN—Alumni Room
7:30 to 9:00 p.m.

This special event is sponsored by the Illinois Fertilizer and Chemical Association.

If you are in town, say hello to old friends, meet new friends, and visit with the speakers.

SPECIAL NOTE FOR MEMBERS OF THE PRESS

Ramada Inn guest rooms are reserved for members of the press; Tony Fitzpatrick is in charge, 8:00 a.m. to 9:00 p.m.

Formal Program

Illini Union, Illini Rooms

WEDNESDAY, JANUARY 5, 1983

PETE PETTY, PRESIDING

8:30 a.m.	Slide Presentation—Hillsboro Warehouse Fire	W.H. Busch	
8:45	Slide Presentation—Ottawa Warehouse Fire	G. Baker	
9:00	Pests of the Home Vegetable Garden and Their Management		
	9:00 Insects	R. Randell	
	9:15 Diseases	M.C. Shurtleff	
	9:30 Weeds	H.J. Hopen	
9:45	Welcome	W.R. Oschwald	
9:55	Recognition of 33-, 34-, and 35-year attendees	W.R. Oschwald	
60 10:00	Coffee		

DON HOLT, PRESIDING

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12:30	Lunch		

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PAUL RISSER, PRESIDING

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DICK FORD, PRESIDING

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TUESDAY, JANUARY 6, 1983

ROGER YOERGER, PRESIDING

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Who's Who

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Brown, C.M., Professor of Plant Breeding, Department of Agronomy, University of Illinois

*Bode, L.E., Associate Professor of Agricultural Engineering, University of Illinois

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Todhunter, J.A., Assistant Administrator for Pesticides and Toxic Chemicals, United States Environmental Protection Agency, Washington, D.C.

**Tomlinson, W., President, Illinois Ground Sprayers Association, Tomlinson Fertilizer, Rushville, Illinois

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White, D.G., Associate Professor of Plant Pathology, University of Illinois

Yoerger, R.R., Professor and Head, Department of Agricultural Engineering, University of Illinois

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**Extension Agricultural Pesticide Planning Committee member.*

***Custom Spray Operators Training School Committee member.*

Thirty-Five Years of Progress

T. Fitzpatrick

The year was 1949. Harry Truman was president of the United States. Ezzard Charles was heavyweight champion of the world. The New York Yankees defeated the Brooklyn Dodgers four games to one to become world champions of baseball. Abroad, U.S. troops were withdrawn from Korea, only to return in 1950. On September 1, the Soviet Union exploded their first atomic weapon, although America was still clearly the most powerful country in the world; on October 1, mainland China became a communist country. Eleven people were convicted of treason for the violent overthrow of the U.S. government, heralding an era of suspicion in the United States. On the brighter side, the post-war baby boom was in full swing, and people were "keeping up with the Joneses" by purchasing television sets, the most coveted social invention since the automobile.

It was in this era of rapid cultural change that the very first Illinois Custom Spray Operators Training School was held at the old Agricultural Engineering Building. The attendance was a modest 358, yet that turnout forced Pete Petty and Walt Scott, the "prime movers" of the early days of Spray School, to find a bigger room to contain the increasing crowds that attended each passing year. Attendance jumped to 545 in 1955, 750 in 1960, 1,034 in 1965, 1,375 in 1972, and the all-time high of 1,705 in 1977. In all, roughly 34,000 people have attended since 1949, a figure that approximates the current total enrollment of the University of Illinois at Urbana-Champaign.

The 35 years of Spray School have seen dramatic changes in agriculture. In 1949, Illinois farmers produced 499,608,000 bushels of corn on 9,250,000 acres for a statewide average of 54 bushels per acre. In that same year, the state's farmers produced 83,818,000 bushels of soybeans on 3,287,000 acres for a statewide average of 25.5 bushels per acre. Compare those figures with the 1982 state average of 136-bushel corn on 11 million acres and 38-bushel soybeans on 9 million acres, and it is easy to see that Illinois farmers in 1949 were only at the beginning of the era of "big-time" farming. Agriculture, like the country as a whole, would never be the same again.

The use of pesticides was perhaps the most revolutionary aspect of the new agriculture. In 1949, the common insecticides were DDT, BHC, chlordane, toxaphene, aldrin, heptachlor and various botanical compounds; the common herbicides were 2,4-D, 2,4,5-T, TCA, dinitro, IPC, and PCP. Some of these agents, like DDT, are no longer part of the scene; others, like 2,4-D, are still with us, as viable as ever. Many more have been added to the canon, along with numerous, beneficial changes in management practices of pesticides and farming operations. The most important indication of progress and of the impact of pesticide usage is that farmers and ultimately the entire American public are dependent on the wise use of pesticides. It should be clear to those who would like to turn back time to this earlier era that we cannot.

Much has transpired in the 35 years of progressive discussion on the use of pesticides here at Spray School. There have been revolutionary methods of application, changes and amendments in laws, and important insect, weed, and plant disease developments. We coped with corn borer scares in the early 1970s; rootworm and cutworm problems in the late 1970s; the southern corn leaf blight epidemic of 1970; the emergence of the soybean cyst nematode as a serious problem throughout the state in the late 1970s and early 1980s; and many, many more problems.

The key upshot of all the years of progress is the current practice that is known as integrated pest management. It combines management practices such as crop rotation, biological controls such as the use of parasites and predators, and the longstanding theme of Spray School -- "the wise and judicious use of pesticides" -- in fighting agricultural pests. With open minds some 1,500 people return year after year to learn and refresh memories on how to carry out this concept and many others.

And so in 1983 we meet again to see the familiar faces of past years, to honor long-time attendees, to renew friendships, and to rekindle knowledge of our trades. We do so in the spirit of nostalgia to commemorate a milestone of 35 years, but we meet also with an eye to the future. While it's fun to look back, it's necessary to look ahead, and that has been the essence of Spray School these 35 years.

Honor Roll

The Custom Spray School means many things to the people who attend each year. While it is a way of furthering one's education and keeping up with the agribusiness industry and acquaintances, it also is a way of marking time. For those who have more or less made a habit of attending the Spray School, the turning of each year means not only beginning a new agricultural year but also attending another Spray School. There are hundreds who have shown loyal support for the yearly program, but there is a special group that has attended longer than the rest; some, in fact, have been supporters right from the beginning. Following is a list of these steadfast supporters who have attended for 33 years or more.

Lillard Hedden, an agricultural pilot and owner of Hedden Agricultural Aviation in Pekin, Illinois, is a 35-year attendee of the Custom Spray School. Lillard started flying in 1940 and went into agricultural aviation at the end of World War II. He has flown nearly 20,000 hours, a world record for agricultural-related flying hours. He has taught seminars on agricultural aviation in the United States, Canada, and several European countries. He also is the author of a manual on aircraft distribution of pesticides, which has been printed in seven languages and is the official government manual of agricultural aviation in three countries.

Howard B. "Pete" Petty, professor emeritus of agricultural entomology, is a 35-year supporter of and participant in the Custom Spray School who continues to work part-time for agricultural entomology. Pete maintains a home in Urbana and one in Ontario, Canada, and devotes a good deal of time to vacationing, fishing, boating, and following University of Illinois athletics.

Dean Roy, a 34-year supporter, is manager of the Rochelle branch of Cole Chemical Supply and a veteran of 36 years in the agricultural chemical business. Dean has been active in the Midwest Agricultural Chemical Association since its beginning, has been a president of that group, and has a permanent award named in his honor (the Dean Roy Salesmanship Award). He also has served on the board of the Illinois Fertilizer and Chemical Association and has been active in that organization for many years.

Fred W. Slife, professor of Agronomy at the University of Illinois since 1947, is a 35-year Custom Spray School attendee. He has taught and conducted research in the area of weed science since 1947. He received a B.S. in 1947, M.S. in 1949, and Ph.D. in 1954, all from the University of Illinois.

John W. Pool, owner of a chemical company that bears his name in Melvin, Illinois, has been in the business since 1948. Popular first-year products, he notes, were 2,4-D and DDT. In addition to his own business, he has managed ten Illinois anhydrous ammonia facilities. He and his younger son, Greg, also farm 800 acres. John has been attending the Custom Spray School for 34 years.

Ray Le Beck, a farmer-dealer located in Montgomery County, has attended the Custom Spray School for 33 years.

M.P. Bishop is retired from Bishop's Fertilizer, a company he founded in Bloomington, Illinois. He is a 34-year attendee.

Weldon Wadleigh, a retired salesman from Stauffer Chemical Company, has attended the Custom Spray School for 33 years.

W. Keith Walker, a salesman for Good Life Insurance in Effingham, has been a supporter for 35 years.

Robert Rider, a salesman with Thompson Hayward Company in Davenport, Iowa, has been coming to the Custom Spray School for 35 years.

W.O. Scott, professor emeritus of agronomy, works part-time at Illinois Foundation Seeds in Champaign and has been involved with the Custom Spray School since 1951.

1983 Urban Pesticide Dealers and Applicators Clinics

Sponsored by the College of Agriculture, University of Illinois at Urbana-Champaign; the Illinois Natural History Survey; and the Illinois Department of Agriculture, Division of Plant Industries

A series of one-day clinics have been held in about 10 locations over the state during the past 10 years. These clinics are educational meetings for dealers and applicators responsible for the control of ornamental and turfgrass pests, the selection and calibration of application equipment, and similar problems of pest control. You are again invited to attend one of the pesticide clinics held in Illinois. The topics of the urban pesticide clinic program are geared for persons who sell or apply pesticides to nonagricultural areas such as home landscape plantings, lawns, golf courses, parks, city streets, highways, and industrial sites. Below are the dates and locations of the nine clinics being held in 1983. We look forward to seeing you at one of them.

Date	City	Location
Fri. Jan. 7	Urbana	Illini Union, University of Illinois 1301 West Green Street
Mon. Jan. 10	Peoria	Farm Bureau Building 1716 North University Exit 91, Interstate 74
Tues. Jan. 11	Springfield	U. of I. Extension Office (4-H Bldg.) Illinois State Fairgrounds
Wed. Jan. 12	Belleville	Belleville Area Junior College 2500 Carlyle Road Route 161 East and Green Mount Road
Thurs. Jan. 13	Mt. Vernon	Rolland Lewis Community Center 27th Street in City Park
Tues. March 1	Moline	Holiday Inn Interstate 280 and Airport Exit
Wed. March 2	Rockford	Henrici's Clock Tower Inn Interstate 90 and Business 20
Thurs. March 3	Wheeling	Chevy Chase Club House 1000 North Milwaukee Avenue
Fri. March 4	Joliet	Holiday Inn East Larkin Avenue and Interstate 80

There will be a 1983 Urban Pesticide Dealers and Applicators Clinic manual. It will include category manuals for ornamental pest control, turfgrass pest control, and right-of-way pest control. The manual will also contain the 1983 pest control suggestions for trees, shrubs, flowers, turfgrass, and other nonagricultural crops. Research results of pest control as well as new fact sheets will be included in the Urban manual. Persons interested in more information to study for the general standards examination should obtain a copy of the *Illinois Pesticide Applicator Study Guide*. It will be available at the registration desk.

Registration will begin at 8:00 a.m. at each location. There will be a registration fee of $7.00 to cover the cost of the Urban manual and the rental of meeting rooms. Advance registration is required for the meeting at Wheeling on March 3. For reservations contact James Fizzell, 4200 W. Euclid, Rolling Meadows, IL 60008. The charge for the March 3 meeting will be $13.00, which includes lunch.

Urban Clinic Program

8:00 a.m.	Registration		
8:30	General Standards Examination		
	Room A		Room B
9:45	Turfgrass Pesticide Applicator Category Training	9:45	Right-of-Way Pesticide Applicator Category Training
10:45	Break	10:45	Break
11:00	Ornamentals Pesticide Applicator Category Training	11:00	Spray Nozzles and Sprayer Calibration
12:00 noon	Lunch (General standards test grades announced)	12:00 noon	Lunch (General standards test grades announced)
1:00 p.m.	Update on Research and Recommendations for Ornamental and Turfgrass Pest Control	1:00 p.m.	Review of General Standards and Applicator Category Training
2:45 p.m.	Examination for Applicators and Operators		

Speakers who will appear on the program at each Clinic are: Loren Bode, Department of Agricultural Engineering; Tom Fermanian, Department of Horticulture; Roscoe Randell, Department of Agricultural Entomology; Malcolm Shurtleff, Department of Plant Pathology; Dave Williams, Department of Horticulture; and various personnel of the Illinois Department of Agriculture.

The present Illinois law requires a person who applies a pesticide for hire outside of a structure to be licensed by the Illinois Department of Agriculture. The speakers on the above program will discuss information that will aid in training persons wishing to take exams in the following categories: forest pest control, ornamental pest control, turfgrass pest control, and right-of-way pest control. Applicators who take and pass the general standards examination at the morning session can take category exams at the end of the sessions. Operators need only to pass the general standards examination. Exams for all categories will be available at the clinics. The examination for Illinois custom spray applicators' and operators' licenses will be given by representatives of the Illinois Department of Agriculture at the end of the meeting. There is no fee for persons taking the licensing exam. Any *applicator* who was first examined and issued a license in 1978 or before will be required to take the new certification examination in 1983. Note: Licensed *operators* do not retake a written exam until 1986.

Persons interested in obtaining a mosquito pest control category license should contact Harvey Dominick, Illinois Department of Public Health, 535 Jefferson Street, Springfield, IL 62706 (phone: 217/782-4674) for locations of mosquito category training meetings.

1983 Agricultural Pesticide Dealers and Applicators Clinics

Sponsored by the College of Agriculture, University of Illinois, the Illinois Natural History Survey, and the Illinois Department of Agriculture, Bureau of Plant and Apiary Protection.

As a pesticide dealer or applicator, you are invited to attend one of the area agricultural chemical clinics. Researchers and Extension Specialists from the University of Illinois will discuss new application equipment and techniques, as well as new research and current suggestions for controlling weeds, insects, and diseases affecting crops.

Current Illinois law requires that a person who applies a pesticide for hire or as part of his or her job responsibilities outside a structure be licensed by the Illinois Department of Agriculture. The categories for commercial and public pesticide applicators and operators are listed below. Individuals wishing to take any exams for licensing in categories 1 through 15 may attend the Agricultural Clinics.

1. Field Crop Pest Control Applicator or Operator
2. Demonstration and Research Pest Control Applicator
3. Regulatory Pest Control Applicator
4. Seed Treatment Pest Control Applicator or Operator
5. Livestock Pest Control Applicator or Operator
6. Fruit Crop Pest Control Applicator or Operator
7. Vegetable Crop Pest Control Applicator or Operator
8. Ornamental Pest Control Applicator or Operator
9. Turf Pest Control Applicator or Operator
10. Plant Management Pest Control Applicator or Operator
11. Aquatic Weed Pest Control Applicator or Operator
12. Right-of-Way Pest Control Applicator or Operator
13. Forest Pest Control Applicator or Operator
14. Grain Facility Pest Control Applicator
15. Aerial Applicator*

The General Standards Certification examination will be given by representatives of the Illinois Department of Agriculture at 8:00 a.m. Everyone must pass this exam before they will be allowed to take a category examination.* The grades for the

**Aerial applicators must take and pass the General Standards and Aerial Applicator exams before taking any other category examinations.*

General Standards exam will be posted during lunch. Those who fail the first time will have an opportunity to study from 1:00 to 3:00 p.m. and retake the exam at 3:15 p.m. Category examinations, for example the Field Crop Pest Control Applicator exam, will be given at 3:15 p.m. There is no fee for persons taking the licensing exams administered by the Illinois Department of Agriculture.

Any Applicator who was first examined and issued a license in 1978 or before is required to pass the new certification examinations in 1983. Persons currently licensed as Operators will need to be retested in 1986 and every five years thereafter.

We look forward to seeing you and discussing problems of mutual interest. The following are the dates and locations for the clinics.

Date	City	Location
February 10	Champaign	Rec-Arena Rt. 45S
February 14	Bloomington*	Moose Hall Veterans Pkwy & Rt. 9
February 15	Jacksonville*	Black Hawk Restaurant Rt. 104
February 16	Collinsville	Holiday Inn Jct. I-55-70 & IL 157
February 17	Mt. Vernon	Community Center City Park, 27th & Logan
February 18	Teutopolis*	Knights of Columbus Hall S. of Rt. 40 on Vine St.
February 22	Morris	Holiday Inn Jct. I-80 & IL 47
February 23	DeKalb	Farm Bureau Building 315 N. Sixth St.
February 24	Dixon	Loveland Community Center 513 W. Second St.
February 25	Galesburg*	Holiday Inn 2 mi. West of I-74 on U.S. 34

*Lunch will be available at these locations.

The registration fee will be $6 per person and will include a draft copy of the *Illinois Pesticide Applicator Training Manual for Field Crops*. The *1983 Thirty-Fifth Illinois Custom Spray Operators Training School* manual will be available for $8.00. The *Illinois Pesticide Applicator Study Guide* can be purchased at the clinic or from your local county Extension adviser for $2.00. Luncheons are extra.

The program for the clinics is shown below.

Agricultural Pesticide Dealers and Applicators Clinic Program

7:30 a.m.	Registration	
8:00	General Standards Certification Examination	Illinois Department of Agriculture
9:30	Break	
9:45	Welcome	Host County Extension Adviser
9:50	Review of General Standards Exam	Charles MacMonegle
10:30	Calculation and Calibration	Loren Bode
11:15	Field Crop Pesticide Applicator Training	Marshal McGlamery
12:00	Lunch	
1:00 p.m.	New Advances in Plant Disease Management	Walker Kirby or Tom Melton
1:30	Synthetic Pyrethroids	Kevin Steffey
1:45	Insect Control Recommendations--1983	Kevin Steffey
2:00	Postemergence Weed Control and Methods of Application	Marshal McGlamery and Loren Bode or Steve Pearson
2:30	Weed Control in Conservation Tillage Methods and Application Options	Marshal McGlamery and Loren Bode or Steve Pearson
3:00	Pesticide Laws and Regulations--1983	Illinois Department of Agriculture
3:15	Examination for Custom Spray Applicator License and General Standards Test	Illinois Department of Agriculture

Prepared by the Agricultural Pesticide Dealers' and Applicators' Committee of the College of Agriculture, University of Illinois at Urbana-Champaign, Illinois Natural History Survey, and Illinois Department of Agriculture, Division of Plant Industries.

Workshops Offered in 1983

Ninth Annual Illinois Crop Protection Workshop

Extension specialists and research personnel of the University of Illinois, College of Agriculture, and the Illinois Natural History Survey are offering a Crop Protection Workshop from March 8 to 10, 1983, at the University of Illinois Illini Union, Urbana. Advance registration will be required.

The objectives of the workshop are to give in-depth training in diagnosing pest problems, troubleshooting in the field, and identifying insect, weed, and disease pests, as well as life cycles, thresholds, plant nutrient deficiencies, and other factors that affect crop production decisions.

Specialists in entomology, weed science, agronomy, and plant pathology from the University of Illinois and the Illinois Natural History Survey will conduct training sessions on the above topics. Out-of-state speakers will also give presentations on subjects of particular interest. About eighteen hours will be spent in group sessions and six hours in the laboratory.

The registration fee for the workshop is $30.00 and will include the cost of the workshop but will not cover meals or lodging. Further information about the workshop can be obtained at the registration desk at the Custom Spray Operators Training School or from Stephen P. Briggs, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820 (Phone: 217/333-6651).

Field Crop Pest Management Scout Training Schools

Two sessions of a pest management scout training short course will be offered in 1983. These short courses are being offered at two separate times to accommodate those persons who will monitor field crops for pest problems. The courses will be taught by Extension specialists in weed science, agronomy, entomology, and plant pathology from the University of Illinois and the Illinois Natural History Survey. The dates of the short courses are:

Scout School I — March 28-29, 1983

Scout School II — March 30-31, 1983

The material presented will be identical for both sessions. Further information about the workshop can be obtained at the registration desk at the Custom Spray Operators Training School or from Stephen P. Briggs, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820 (Phone: 217/333-6651).

Entomology Workshop

Extension specialists and research scientists from the University of Illinois and Illinois Natural History Survey will be offering an advanced entomology short course on the Urbana-Champaign campus July 27 to 28, 1983.

The primary emphasis of the 2-day course is to provide in-field training on a number of entomological techniques. Approximately one-half of the time will be spent in the field. Some of the topics that will be covered include sampling insects in narrow- and wide-row soybeans, determining defoliation levels in soybeans, sampling rootworm beetles, evaluating rootworm insecticides, scouting for European corn borers, sampling for potato leafhoppers, and observing phytotoxicity to plants caused by insecticides.

Some of the classroom discussions will concern the computer simulation model for black cutworm development, the identification of major and minor insect pests of field crops, and the natural biological control agents.

A registration fee of $25 will include the cost of the workshop but will not cover meals or lodging. Optional materials available to the participant will include a sweep net, beat-cloth, hand lens, and numerous publications.

Class size will be limited to 40 people, so advance registration will be required. Further information about this short course can be obtained at the registration desk at the Custom Spray Operators Training School or from Stephen P. Briggs, Illinois Natural History Survey, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820 (Phone: 217/333-6651).

Which Workshop Is For You?

Each year a number of people inquire about the difference between the crop protection workshop and the pest management scout training short course.

The Crop Protection Workshop is intended for those individuals who are concerned with the research that goes into pest management. Topics presented are more formal and represent the current research and ideas that will provide the basis for future pest management decisions. Each evening, three one-hour laboratory sessions cover topics that you have chosen on your registration form. Farmers, agribusiness people, and Extension advisers represent the largest portion of the 400 people in attendance.

The Field Crop Pest Management Scout Training short courses are intended for those who wish to learn the what, how, where, and when of field crop scouting. The lab sessions are approximately four hours each and cover in depth the identification of weeds, insects, and plant diseases and the procedures needed to accurately scout and report the findings. Farmers and field scouts employed by private consultants comprise the largest segment of the audience.

If you are still unsure about which workshop to attend, contact Stephen P. Briggs, Illinois Natural History Survey, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820 (Phone: 217/333-6651).

Newsletters from University of Illinois, College of Agriculture

FARM ECONOMICS FACTS AND OPINIONS—Economic principles applied to farm problems such as pricing strategy, crop production costs, and market outlook. Issued monthly.

WEEKLY OUTLOOK—Anticipates reports and interprets current market information--supply, demand, and price outlook--for agricultural products. Issued weekly except for last two weeks of December.

OUTLOOK UPDATE—Four issues each on soybeans, corn, cattle, and hogs; timed to coincide with inventory reports for each commodity. Presents an in-depth look: entensive statistical tables, current forecasts, price-forecasting methods, forecasts of prices and price changes, and evaluation of forecasts. Also includes discussions of pricing strategies. Sixteen issues per year.

ILLINOIS IRRIGATION NEWSLETTER—Presents information on new irrigation techniques and equipment and some in-depth treatment of specific topics of interest to irrigators. Issued ten times per year.

SWINE REPORT—Current information on feeding, management, economics, and engineering. Issued quarterly.

BEEF REPORT—Current information on feeding, breeding, management, and engineering. Issued quarterly.

ILLINOIS DAIRY DIGEST—Provides the latest dairy research information available from the University of Illinois and other sources; practical, timely tips to help dairymen make management decisions; announcements of educational events of interest to producers. Issued 4 times per year.

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ILLINOIS NURSERY NOTES—Nursery news and timely tips for commercial nurserymen and landscape contractors. Issued four times per year.

INSECT, WEED, AND PLANT DISEASE SURVEY BULLETIN—Weekly reports include the current agricultural insect, weed, and plant disease situation with advice in control methods. New developments in pesticide application techniques included. Issued weekly April through August; 20 issues.

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SPRAY SERVICE REPORT—Provides information on commercial fruit culture, insect and disease problems, and recommended control measures. Issued weekly March - May, bi-weekly June - August 15, with special issues September - February, 17 issues per year.

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Herbicides for Reduced Tillage

F.W. Slife

In the past five years the trend toward some form of reduced tillage has rapidly progressed. The use of no-till has increased slowly but steadily, while the shift to chisel plowing has been dramatic. Because no-till farming has been around for a number of years, no-till weed control programs have become standardized, and we are doing about as much as is possible with the herbicides available. In the case of chisel-plowed fields, particularly those in corn, we are in a trial period where different weed control treatments are being compared. For the most part, we have simply transferred the treatments previously used in clean-tillaged fields to the chisel-plowed fields. These treatments have worked very well where soybean stubble has been involved, but they have worked a little less satisfactorily where corn stubble has been chiseled. New incorporation tools offer considerable promise of leaving some crop residue on the surface while incorporating the herbicide.

One of the major problems in chisel-plowed fields arises from our strong trend toward early planting of both corn and soybeans, but particularly corn. Early planting is essential for maximum yields, but it also helps avoid late planting caused by untimely rainfall. When crops are planted early where significant crop residue is left on the surface, as it is in chisel-plowed fields, darker soils tend to be colder and not to dry out as fast as in clean-plowed fields. These colder, wetter soils are not as favorable for preplant-incorporated herbicides, particularly because of the strong trend toward single-pass incorporation. Both the interference from the crop residue and the moist, cloddy soil tend to make good herbicide distribution difficult to achieve. Increased rates of application have helped, but they have not completely solved the problem. An additional incorporation would likely improve herbicide performance, but additional incorporation would also decrease the amount of surface crop residue and hence increase the erosion potential.

One of the longer-term problems that confront us in reduced tillage systems is the increased production of both annual and perennial weed seeds. Under clean-tillage systems, many producers were able to reduce the weed seed population dramatically with herbicides and tillage. The result of the reduction was much less weed pressure since soil-applied herbicides tend to perform better with lower weed germination. Preventing weed seed production each year drastically reduces weed-seed levels. Some fields in reduced tillage tend to have more weeds, but these weeds generally do not reduce yields because the total population is low. If the trend toward more weeds continues, then the potential weed problem will become more serious because of increased seed production.

Weed Control in No-Till Fields

There are no major changes in the basic weed control program for 1983. A knock-down treatment, a preemergence application of a grass and broadleaf herbicide, and a post application if needed make up the basic program. Two new herbicide treatments will be useful.

The new postemergence grass killers for use in soybeans should find immediate use in the johnsongrass and wild cane areas. These herbicides will also probably be used in some fields to clean up grass infestations resulting from partial failure of the preemergence grass herbicides. They have at least some potential of replacing the soil-applied grass herbicides, but further work in this area is needed.

The second new treatment, Dowco 356 plus atrazine applied postemergence, is a very satisfactory treatment for both annual grass and broadleaf weeds in corn. This treatment should have an Experimental Use Permit in 1983. This herbicide combination has some potential as the primary treatment in no-till corn, but most likely it will be used in the initial stages as a clean-up postemergence treatment where needed.

Weed Control in Chisel-Plowed Fields

There are no major changes in the basic weed control options for chisel-plowed fields in 1983. The basic program is still a preplant or preemergence herbicide followed by a row cultivation and a postemergence herbicide as needed. New postemergence grass herbicides for soybeans and postemergence treatments of Dowco 356 plus atrazine for corn are additional treatments that can be used. At the present time, and for at least the near future, we will have to rely on tillage for at least part of our weed control program. Spring tillage on chisel-plowed fields will generally be more economical than a knock-down treatment and will also allow us to use incorporated herbicides. We can still use row cultivation in chisel-plowed fields, and this use also may be more economical than applying a postemergence herbicide treatment.

Reduced tillage systems that leave much of the previous year's crop residue on the surface are our major hope of reducing soil erosion. Thus we need to develop improved weed control systems that will sustain and expand the trend toward reduced tillage.

Soil Insect Problems in First-Year Corn Following Soybeans

D.E. Kuhlman and S.P. Briggs

Is it profitable for a farmer to apply a soil insecticide on first-year corn following soybeans?

Each year we receive a few reports and testimonials from farmers and others about yield increases from the use of a soil insecticide on corn following soybeans. In some instances, the yield increases that are reported have occurred in fields without any apparent soil insect problem. Sometimes these reports are made without the benefit of comparing a treated area to an untreated area within the field.

How much risk does a farmer take in not using a soil insecticide on corn after soybeans? For the farmer who wants to reduce or minimize the risk of damage by a soil insect, the investment of $10 to $12 per acre for a soil insecticide represents an insurance policy against the unexpected. Is the insurance policy necessary? A comparison of soil insecticide use on corn after soybeans for 1978 and 1982 offers some insight into this question.

During 1978, approximately 33 percent of the corn-following-soybean acreage in Illinois was treated with a soil insecticide at planting (unpublished data from Major Crop Pesticide Use Survey, University of Illinois, Department of Agronomy, 1978). In 1982, approximately 15 percent of the corn-following-soybean acreage was treated with a soil insecticide, based on a survey of county Extension advisers. The reduction in soil insecticide use in 1982 was primarily dictated by economic considerations. Based on a survey of county Extension advisers, the 1982 reduction in the use of soil insecticides on corn after soybeans apparently did not result in an increase in soil insect problems for most farmers.

Illinois Extension entomologists have estimated the probability of economic soil insect outbreaks on corn for a corn-soybean-corn-soybean rotation as follows:

Insect	Probability
Black cutworms	1:25
Corn rootworms	1:10,000
Wireworms	1:500
White grubs	1:1,000

These "estimates" are based on the assumption that the farmer will do an above-average job of controlling weeds in soybeans and corn. Outbreaks of the above insects, particularly cutworms, are frequently influenced by the presence of weeds in soybean stubble that are attractive to egg-laying adults.

Historically, the incidence of economic infestations of cutworms, wireworms, white grubs, and corn rootworm in corn after soybeans is relatively low. An annual survey of county Extension advisers over the last 27 years indicates that each year, on the average, about 235,000 acres of corn will require a rescue treatment for cutworms and about 86,000 acres will need to be replanted because of cutworm damage. These figures represent about three percent of the total corn acreage in Illinois. Unfortunately, we don't know how many acres of cutworm damage were prevented by preplant or planting-time applications of soil insecticides.

Published data are limited that report yield relationships between treated and untreated portions of fields of corn following soybeans. Petty and Moore (1959) indicated that underground insects of corn reduce yields by five to six bushels per acre each year in Illinois. Bigger and Blanchard (1959), based on a five-year study of 289 cornfields in Illinois, estimated that 38 percent of the fields had economic infestations of soil insects. Bigger and Decker (1966), in comparing yields of treated and untreated portions of 130 Illinois fields from 1954 to 1963, found a yield increase of 6.4 percent for aldrin-treated areas over the yield of the untreated areas. More recently, Turpin and Thieme (1978) collected yield data from 107 randomly selected fields of corn in Indiana and compared yields of the treated and untreated fields. Yields averaged two bushels per acre more in insecticide-treated portions of the field than in untreated portions of the test fields.

Because only limited data are available, we conducted tests in nine Illinois counties during 1982 to determine the effect of soil insecticides on yield in corn after soybeans. In addition to obtaining yield data, we also monitored for cutworms, corn rootworm damage, and first-generation European corn borers. These insecticide tests in corn after soybeans, conducted with the assistance and cooperation of the county Extension advisers and area farmers, were located in Champaign, Christian, Ford, Lee, Logan, Morgan, Ogle, Piatt, and Sangamon counties. George Czapar, area adviser, pest management, assisted with the plots in Lee and Ogle counties.

Materials and Methods

The experimental design used for these tests was a randomized complete block with four replications. The soil insecticides used at each location were Furadan 15G, Amaze 20G, Lorsban 15G, and Dyfonate 20G. Each treatment was applied to a five-row plot that was 150 feet long. An untreated check was included in each replication. Each granular insecticide was applied in a seven-inch band over the row by means of a Noble metering unit mounted on a bicycle-wheeled applicator. The granules were incorporated by a drag chain that trailed behind the bander.

All plots were monitored following seedling emergence to establish the presence of cutworms and to measure plant population levels. Plant populations were taken from the center three rows of each treatment. First-generation European corn borer infestations were recorded during late June, and rootworm damage was evaluated in early July by digging five randomly selected plants from each treatment and assigning root damage ratings. Yield values were based on machine harvest of three rows of each treatment for 150 feet. Grain was weighed in the field using a weigh-wagon. Yield was calculated on the basis of #2 grain (15.5 percent moisture, 56 pounds per bushel) and reported as bushels per acre.

Results

The incidence of black cutworms, first-generation European corn borer, and corn rootworm damage was extremely low at all nine locations during 1982 (Tables 1 through 9). None of these pests exceeded the suggested economic thresholds in the untreated plots. The yields for the different soil insecticides were not statistically different from those of the untreated plot in any of the test locations (Tables 1 through 9). The yield data indicate that prophylactic use of soil insecticides would not have been profitable in any of these fields in 1982 (Tables 1 through 10).

Summary

It is virtually impossible for anyone, including entomologists, to guarantee absolutely that there will be no soil insect pests present in a field of corn after soybeans. However, as pointed out earlier, the probability is low, and the risk to a farmer from not using a soil insecticide is minimal. Obviously, exceptions can be expected occasionally, because soil insect problems are influenced by a variety of factors unrelated to crop rotation, such as weeds, weather, soil type, tillage, and native enemies. Of these factors, good weed control in soybeans is a key in helping to avoid certain soil insect pests. For example, preplant infestations of broadleaf weeds such as chickweed, shepherd's purse, and peppergrass are attractive to cutworm moths for egg laying during March and April. The absence of these weed species at the time cutworm moths are laying eggs won't guarantee a cutworm-free field, but the potential for damage will be reduced.

Cutworms do occur with greater frequency in corn after soybeans than do wireworms, white grubs, and corn rootworms. Fortunately, timely scouting as the corn is emerging will enable most growers to detect cutworm outbreaks and apply a rescue treatment before economic damage occurs.

Wireworm infestations have been appearing with greater frequency in recent years. In perspective, the probability of wireworm damage to corn after soybeans is extremely low in fields of corn. A scouting procedure has been developed for evaluating wireworm potential before planting corn. It involves the use of wheat/corn bait stations buried in the ground at several sites in the field. Wireworms attracted to the bait stations are counted, and treatment decisions are based on the average number per station. Throughout the spring and summer, the adult wireworm (a click beetle) prefers to deposit its eggs in small-grain stubble or grassy areas in fields.

Even though rootworm beetles can be found in "clean" or weed-free soybean fields, and may even lay a few eggs in them, the number of eggs is rarely great enough to warrant the use of a rootworm soil insecticide on corn the following season. However, soybean fields with 5,000 or more volunteer corn plants per acre will usually warrant treatment for rootworm control the following year if planted to corn.

In summary, data from seven tests in 1982 did not show a yield advantage from the use of a soil insecticide in corn following soybeans.

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Table 1. Effect of Soil Insecticides on Insects, Plant Populations, and Yield in Corn after Soybeans, Champaign County, 1982

Treatment	Lbs. a.i./ acre	Plants per acre*	Number of plants cut per acre by cutworms*	Number of 1st gen. corn borer larvae per 100 plants*	Average root rating*,†	Bushels per acre No. 2 corn*
Lorsban 15G	1	26,333 a	0 a	0 a	1.0 a	181 a
Amaze 20G	1	25,250 a	0 a	2 a	1.0 a	175 a
Furadan 15G	1	24,917 a	0 a	2 a	1.0 a	179 a
Dyfonate 20G	1	25,333 a	0 a	0 a	1.0 a	178 a
Check	-	25,583 a	0 a	3 a	1.0 a	185 a

*Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).

†1 = No visible damage or only a few minor feeding scars; 2 = Some roots with feeding scars, but none eaten off within 1-1/2 inches of the plant; 3 = Several roots eaten off to within 1-1/2 inches of the plant, but never the equivalent of an entire node of roots destroyed; 4 = One node of roots destroyed or the equivalent; 5 = Two nodes of roots destroyed or the equivalent; 6 = Three or more nodes of roots destroyed.

Table 2. Effect of Soil Insecticides on Insects, Plant Populations, and Yield in Corn after Soybeans, Christian County, 1982

Treatment	Lbs. a.i./ acre	Plants per acre*	Number of plants cut per acre by cutworms*	Number of 1st gen. corn borer larvae per 100 plants*	Average root rating*	Bushels per acre No. 2 corn*
Lorsban 15G	1	21,958 a	0 a	4 a	1.0 a	177 a
Amaze 20G	1	22,792 a	0 a	3 a	1.0 a	184 a
Furadan 15G	1	22,042 a	42 a	1 a	1.0 a	187 a
Dyfonate 20G	1	22,625 a	0 a	4 a	1.0 a	178 a
Check	-	22,042 a	84 a	8 a	1.1 a	187 a

*Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).

Table 3. Effect of Soil Insecticides on Insects and Plant Populations in Corn after Soybeans, Ford County, 1982

Treatment	Lbs. a.i./ acre	Plants per acre*	Number of plants cut per acre by cutworms*	Number of 1st gen. corn borer larvae per 100 plants*	Average root rating*	Bushels per acre No. 2 corn†
Lorsban 15G	1	21,958 a	0 a	4 a	1.6 c	--
Amaze 20G	1	23,333 a	0 a	1 a	1.2 ab	--
Furadan 15G	1	22,792 a	42 a	1 a	1.1 a	--
Dyfonate 20G	1	22,500 a	0 a	3 a	1.1 a	--
Check	-	21,708 a	42 a	1 a	1.4 bc	--

*Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).
†Data not taken.

Table 4. Effect of Soil Insecticides on Insects, Plant Populations, and Yield in Corn after Soybeans, Lee County, 1982

Treatment	Lbs. a.i./ acre	Plants per acre*	Number of plants cut per acre by cutworms*	Number of 1st gen. corn borer larvae per 100 plants*	Average root rating*	Bushels per acre No. 2 corn*
Lorsban 15G	1	21,958 a	42 a	0 a	1.1 a	158 a
Amaze 20G	1	22,792 a	42 a	0 a	1.1 a	160 a
Furadan 15G	1	22,042 a	0 a	1 a	1.0 a	157 a
Dyfonate 20G	1	22,625 a	0 a	0 a	1.1 a	158 a
Check	-	22,042 a	42 a	0 a	1.2 a	155 a

*Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).

Table 5. Effect of Soil Insecticides on Insects and Plant Populations in Corn after Soybeans, Logan County, 1982

Treatment	Lbs. a.i./ acre	Plants per acre*	Number of plants cut per acre by cutworms*	Number of 1st gen. corn borer larvae per 100 plants*	Average root rating*	Bushels per acre No. 2 corn†
Lorsban 15G	1	24,125 a	0 a	7 a	1.0 a	--
Amaze 20G	1	26,167 a	0 a	4 a	1.0 a	--
Furadan 15G	1	25,375 a	42 a	7 a	1.0 a	--
Dyfonate 20G	1	24,208 a	84 a	10 a	1.0 a	--
Check	-	25,250 a	84 a	21 a	1.0 a	--

*Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).
†Yield data not taken.

Table 6. Effect of Soil Insecticides on Insects, Plant Populations, and Yield in Corn after Soybeans, Morgan County, 1982

Treatment	Lbs. a.i./ acre	Plants per acre*	Number of plants cut per acre by cutworms*	Number of 1st gen. corn borer larvae per 100 plants†	Average root rating*	Bushels per acre No. 2 corn*
Lorsban 15G	1	27,042 a	42 a	--	1.0 a	176 a
Amaze 20G	1	25,500 a	42 a	--	1.0 a	175 a
Furadan 15G	1	24,917 a	0 a	--	1.0 a	179 a
Dyfonate 20G	1	25,042 a	0 a	--	1.0 a	177 a
Check	-	25,167 a	42 a	--	1.1 a	182 a

*Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).
†Data not taken.

Table 7. Effect of Soil Insecticides on Insects, Plant Populations, and Yield in Corn after Soybeans, Ogle County, 1982

Treatment	Lbs. a.i./ acre	Plants per acre*	Number of plants cut per acre by cutworms*	Number of 1st gen. corn borer larvae per 100 plants*	Average root rating*	Bushels per acre No. 2 corn*
Lorsban 15G	1	22,333 a	0 a	0 a	1.2 a	153 a
Amaze 20G	1	22,750 a	0 a	0 a	1.1 a	145 a
Furadan 15G	1	22,500 a	0 a	1 a	1.2 a	152 a
Dyfonate 20G	1	23,958 a	0 a	1 a	1.2 a	152 a
Check	-	22,125 a	0 a	0 a	1.2 a	149 a

*Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).

Table 8. Effect of Soil Insecticides on Insects, Plant Population, and Yield in Corn after Soybeans, Piatt County, 1982

Treatment	Lbs. a.i./ acre	Plants per acre*	Number of plants cut per acre by cutworms*	Number of 1st gen. corn borer larvae per 100 plants*	Average root rating*	Bushels per acre No. 2 corn*
Lorsban 15G	1	22,667 a	0 a	1 a	1.1 a	140 a
Amaze 20G	1	22,083 a	0 a	1 a	1.0 a	137 a
Furadan 15G	1	23,000 a	0 a	4 a	1.0 a	137 a
Dyfonate 20G	1	22,083 a	0 a	1 a	1.0 a	128 a
Check	-	22,458 a	0 a	0 a	1.0 a	133 a

*Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).

Table 9. Effect of Soil Insecticides on Insects, Plant Populations, and Yield in Corn after Soybeans, Sangamon County, 1982

Treatment	Lbs. a.i./ acre	Plants per acre*	Number of plants cut per acre by cutworms*	Number of 1st gen. corn borer larvae per 100 plants*	Average root rating*	Bushels per acre No. 2 corn*
Lorsban 15G	1	23,792 a	0 a	7 a	1.0 a	180 a
Amaze 20G	1	22,083 a	0 a	3 a	1.0 a	182 a
Furadan 15G	1	22,917 a	0 a	19 a	1.0 a	184 a
Dyfonate 20G	1	21,458 a	0 a	2 a	1.0 a	177 a
Check	-	22,083 a	0 a	3 a	1.0 a	180 a

*Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).

Table 10. Summary of the Effect of Soil Insecticides on Insects, Plant Populations, and Yield in Nine Fields of Corn after Soybeans, Illinois, 1982

Treatment	Lbs. a.i. per acre	Average no. plants per acre*	Average no. plants cut per acre by cutworms*	Average no. 1st gen. corn borer larvae per 100 plants	Average root rating*	Average yield, bushels per acre No. 2 corn†
Lorsban 15G	1	24,102	9	3	1.1	166
Amaze 20G	1	23,972	9	2	1.0	165
Furadan 15G	1	23,810	14	4	1.0	168
Dyfonate 20G	1	23,736	9	3	1.0	164
Check	-	23,653	33	5	1.1	167

*Means are for nine fields.
†Means are for seven fields.

1982 Update on Corn Diseases

B.J. Jacobsen and D.G. White

Corn diseases reduced 1982 yields by three to seven percent in Illinois. Dry weather in August and an ideal harvest season reduced potentially dramatic losses from leaf diseases and from stalk rot in particular. Stalk rots were the most important diseases and are thought to be responsible for more than two-thirds of the total yield loss. Leaf diseases of economic importance included northern leafspot, southern corn leaf blight, common rust, southern rust, grey leafspot, eyespot, and northern corn leaf blight. Damage from nematodes was not as apparent as in previous years except for sandy soil areas, where significant damage occurred. Storage mold problems were common in stored 1981 crop corn.

Stalk Rots

Several factors contributed to the stalk rot problems encountered in 1982. These include high yields and cloudy weather in July and August, loss of nitrogen early in the growing season, and loss of leaf tissue to leaf diseases. The stalk rot fungi associated with the problems are, in order of importance, *Gibberella zea* (Gibberella stalk rot), *Colletotrichum graminicola* (anthracnose stalk rot), *Diplodia maydis* (Diplodia stalk rot), and *Macrophomenia phaseolina* (charcoal stalk rot).

Stalk rot diseases reduce yields in two ways. The first is by prematurely killing plants, thereby reducing the grain-fill period and creating light test-weight grain. Corn affected by stalk rot diseases is subject to more mechanical damage and thus more storage mold problems.

The second way stalk rots reduce yields is through harvest losses. These losses occur because there are more dropped and rotted ears and because slower-than-optimal harvest speeds have to be used. Ears that are in contact with soil are more subject to ear rot.

Stalk rot problems were anticipated as early as mid-August. This anticipation was based on recent stalk rot research by Dr. James L. Dodds, plant pathologist for PAG Cargill, and others. This research has shown that stalk rot can be anticipated where (a) the corn plant commits itself to a high yield because of a favorable environment in the period from planting through pollination and (b) the post-pollination period is cloudy, or other factors limit photosynthesis or maximum plant function. This concept can be best understood by examining basic corn plant physiology.

The number of kernels that an individual corn plant produces is determined at two critical stages: one at the 8- to 10-leaf stage and the other at pollination. At the 8- to 10-leaf stage, both ear size and the number of ovules or potential rows of kernels are determined. At pollination, the number of fertilized ovules (kernels) per row is determined. The number of kernels set is of importance because the kernels are the primary site for deposition of photosynthetiates. In fact, the sugar demands of the developing kernels are met before other plant needs. Therefore, if insufficient sugar is produced by the plant, other plant parts, such as root and stalk tissue, will be short of vital sugar. Tissues that are short of sugar die prematurely and are more susceptible to stalk rot fungi.

Factors that limit photosynthesis or other critical plant functions include lowered light intensity as a result of cloudy weather, loss of leaf tissue from disease, insects or hail, a deficiency in potash, phosphorus, nitrogen, or other critical nutrients, and a shortage or excess of water.

Light intensity is critical for maximum photosynthesis in corn. The corn plant photosynthesizes at 100 percent at approximately 10,000 foot candles (bright sunshine), at 80 percent under light overcast, and at 40 percent under overcast conditions. Therefore, under cloudy conditions during the post-pollination period, sugar deficiency can occur if kernel demand (number) is as high as it was in both 1981 and 1982. Another perspective is that under cloudy conditions the plant often uses more sugar to fuel plant functions than is produced by photosynthesis during the day.

Loss of leaf tissue can directly influence the development of stalk rot and the ultimate yield. Because leaves above the ear are the most critical to grain fill, damage to these leaves is most critical in reducing yields and inducing stalk rot. The critical time period is the approximately 55 days from pollination to black layer formation. The following leaf diseases were important in 1982 in the development of stalk rot in some hybrids: common rust, southern rust, southern corn leaf blight, northern corn leaf blight, grey leaf spot, eyespot, northern leaf spot, and anthracnose leaf blight. Leaf loss from insects, hail, frost, and other causes can have equally damaging effects.

The role of nutrients in the development of stalk rot problems is very important. The vast majority of research has been done on the relationship between nitrogen and potassium. In general, research has shown that high nitrogen and low potash availability promotes stalk rot problems. Potassium is critical to the production of sugar by photosynthesis since it is a catalyst for many of the enzymic reactions that take place during photosynthesis. Research has additionally shown that cell walls are thicker when potassium levels are adequate. These thicker cell walls slow fungal invasion and create a mechanically stronger plant. Reduced use of potassium-containing fertilizer in recent years and maintenance of high levels of nitrogen may now be resulting in increased stalk rot problems.

It is important to realize that soil tests do not always reflect the availability of potassium or its levels in leaf tissue. For maximum photosynthesis, leaf tissues should contain 1.5 to 2.0 percent potassium. Potassium availability and uptake can be reduced by dry soils, cool soils, acid soils (a $pH < 5.0$), and soils with poor aeration.

In 1982, loss of nitrogen due to denitrification may have also stressed plants in the post-pollination period. In addition, the dry weather that predominated in many areas of Illinois during late July and early August may have further stressed plants that had a high demand for sugar because of their high yield potential established earlier in the growing season. Stress of any kind during grain fill tends to predispose plants to stalk rot.

Other factors that may predispose a plant to stalk rot problems are planting at too high a population for a particular hybrid in a particular environment, poor control of insect pests such as corn borers, and damage from corn nematodes.

Planting at too high a population results in thinner stalks with less mechanical strength and in limited photosynthesis if plant architecture is not designed for dense plantings.

Corn borers can increase stalk rot problems in two ways: (1) by cutting the flow of sugars from the leaves to the developing grain by direct feeding, and (2) by providing stalk rot fungi access to stalk tissues, either by directly carrying stalk rot fungi into the pith or by opening wounds to the outside.

Root damage by corn nematodes after pollination will stress plants. Root lesion and lance nematodes may be involved in stalk rot problems.

Foliar Diseases

Until the dry weather of late July and August, 1982 was ideal for the development of foliar diseases. As evidence, it is estimated that more seed corn fields were sprayed with fungicides than at any time since the southern corn leaf blight epidemic of 1970.

Common rust was epidemic throughout Illinois in 1982 because of the following reasons. For one, common rust blew in from the southern states much earlier compared with its arrival in most years. This year rust could be found as early as the third week of May compared with a more common appearance in late June or July. Two, weather conditions were ideal, with frequent rains and cool temperatures prevailing through May, June, and early July. Third, susceptible germplasm was widely used.

The genetic susceptibility of commonly planted genotypes to common rust stems from the replacement of the inbred B14A, the best source of common rust resistance, with other inbreds in recent years. Another factor, which is more difficult to document, is that "older" corn breeders recognized common rust as a serious disease and they placed a strong emphasis on resistant genotypes. "Newer" breeders, who have not seen significant damage from this disease since the late 1950s (owing to the widespread use of B14A or other closely related inbreds), have placed less emphasis on resistance. It is likely that breeders will once again reemphasize resistance to common smut.

Southern rust appeared late in the season and did not affect yields significantly.

Leaf diseases that influenced yield included southern corn leaf blight, grey leaf spot, anthracnose leaf blight, eyespot, and northern leaf spot. Grey leaf spot was found primarily in northwestern Illinois; this finding was unexpected since previous to 1982 it was found only in river bottom areas in far southern Illinois. Grey leaf spot is favored by warm to hot humid conditions and has been most prevalent in no-till or minimum tillage fields from Virginia to Missouri. This year, extensive disease development was reported in Iowa.

Southern corn leaf blight caused damage as far north as central Illinois where rainfall favored disease development. The use of resistant germplasm greatly limited damage from this disease. In future years more hybrids will be available with resistance from the "rhm" gene.

Anthracnose leaf blight and eyespot were common in central and northern Illinois. The leaf blight phase of the anthracnose disease can be controlled by crop rotation or through resistance. While eyespot was common on leaves below the ear, the disease caused little yield loss. Most widely used genotypes are not highly susceptible to the disease and are, in fact, at least moderately resistant in that disease development is slow enough and lesion size is small enough to avoid yield losses.

The northern leaf spot disease (*Helminthosporium carbonum*) was common, particularily in northern Illinois. Although the disease was widespread in occurrence, there are relatively few hybrids that are susceptible enough for serious yield losses to occur. Again, most hybrids would be classed as moderately susceptible to moderately resistant based on disease development and yield loss potential.

Northern corn leaf blight (*Helminthosporium turcicum* race 2) was very common and widespread in 1982. However, the disease appeared too late to cause losses in all but late planted sweet corn. Many hybrid producers are now utilizing germplasm carrying either polygenic resistance or conditioned by other genes for resistance.

Growers who suffered yield losses from diseases should first consider the selection of resistant hybrids and crop rotation as means of control. The use of clean plowdowns should be considered only when the above controls are not feasible. The use of foliar applications of fungicides is rarely economically feasible for hybrids but may be a valuable control tool in seed corn production fields.

Varying Preemergence Herbicide Rates for Changes in Soil Organic Matter

E.J. Matthews

The use of soil-applied herbicides in agricultural production is steadily increasing. Preplant and preemergence herbicides are used with most field crops grown in commercial production. The costs of both herbicides and their application have increased a great deal in the past ten years, along with the increased cost of petroleum products. These cost increases put considerable pressure on farmers to apply herbicides more efficiently so that just enough herbicide is used to achieve the desired weed control without unduly increasing costs by excess application rates.

Researchers generally agree that the amount of herbicide needed to achieve good weed control is largely determined by the carbon content of the soil. High-carbon soils require a higher herbicide application rate than do soils with a lower carbon content. Generally, no problems are associated with herbicide application rates in fields with uniform soils. Such is not the case where soil types vary greatly in only short distances across the field. This condition usually occurs in alluvial soils, which in many cases can vary from almost pure sand to a "gumbo" soil (a heavy, black, colloidal clay soil), with the transition taking place in less than 50 feet. This variation requires changing the herbicide application rate from minimum to maximum very quickly as the sprayer moves across the field to achieve the optimum application rate on all areas of the field.

Some farmers have attempted to improve their variable rate control by using two spray booms with one boom having larger nozzles than the other. Used singly, the booms give two different rates. A third, higher rate is available by using both booms simultaneously. As the operator crosses the field, he makes a visual estimation of soil type changes and turns the booms on and off as needed. With a good operator, better application can be achieved with this system over the single boom system, but a poor operator can really get bad weed control results. What is really needed is an automatic, mobile, soil-type sensor mounted on the spray machine that would control the spray applied so that the correct amount of herbicide would be applied for the soil type being sprayed at any particular instant.

The need for this type of automatic spray system has not gone unrecognized. Agricultural engineers at the University of Arkansas began research on a soil-type sensor in 1973. Similar investigations began at about the same time in the Agricultural Engineering Department at the University of Illinois. Investigations at both locations were centered on developing a suitable sensor that could be mounted on a spray machine. To be satisfactory, this sensor should accurately determine soil type (and carbon content) at normal field operating speeds and should provide outputs compatible with electronic controls that would then vary the herbicide spray rate as needed.

Solution of the sensor problem appeared easy prior to the initiation of research. In actuality it has proven to be very difficult. After nine years of research at the University of Arkansas, Dr. Griffis has a new sensor that is worth taking from the laboratory to be used on a field test unit. This sensor does quite well in determining soil types under laboratory conditions with soils varying from sand to heavy clays.

Researchers at the University of Illinois have had similar experiences in developing a satisfactory sensor. Their sensor also is still in the laboratory, but development continues.

I would like to conclude on an optimistic note. Although development of a satisfactory, automatic, variable-rate herbicide spray system has not evolved even after nine years of research, development of a satisfactory, soil-type sensor is not impossible; in fact, such a development may be very close. It is still a much-needed machine, just ask the farmers who operate on the 40 million plus acres of alluvial soils that stretch from the Imperial Valley of California to the Carolinas. These farmers need this machine.

Broadleaf Weed Competition in Soybeans

E.W. Stoller

Broadleaf weeds such as common cocklebur, velvetleaf, and jimsonweed are fairly common in soybean fields throughout Illinois, especially since some of these weeds escape many of the widely used weed control practices. Although they are usually not obvious until about the first of August, these weeds grow taller than the soybean canopy and cause unsightly fields and yield reductions.

How much yield reduction can be expected when these weeds infest soybeans? Because a host of factors affect competition of weeds with crops, it is not surprising that the answer is complex.

Some of the factors that affect competition between weeds and soybeans are weed density, crop density, growing conditions, crop variety, weed species, weed morphology, crop morphology, and the length of time weeds compete. We researched several of these factors to determine how weeds exert their competitive influence on soybeans. The results from our experiments and others allow us to understand better how broadleaf weeds compete with soybeans.

Effect of Weed Density

It is obvious that more weeds per unit area mean more yield reduction. Much interest exists in the "economic threshold" of weed infestations, but threshold densities are affected greatly by species of weeds and their environment, making these thresholds difficult to pinpoint. A lot of density data were obtained at weed densities greater than one weed per three feet of row. Densities of this magnitude are not encountered very often in Illinois soybean fields. Our data show that cocklebur is much more competitive than jimsonweed or velvetleaf.

Effect of Reduced Light

One way that these broadleaf weeds can affect the soybeans is to exceed the soybean's height and shade the crop. Our studies show that soybeans can tolerate quite a bit of shade without any reduction in photosynthesis or seed yield. We feel that these weeds exert a greater effect on soybeans by competing for growing space rather than for light.

Effect of Weed Emergence Date

A lot of research data show that no significant crop yield loss occurs from weeds that emerge later than six weeks after planting. Our data show that only the weeds that emerge in the crop row at planting time will grow taller than the crop. If they emerge from the row two weeks after planting, they will not grow taller than the soybeans. If the weeds emerge from between the crop rows two weeks after planting, however, they can grow taller than the crop.

Potential Cutworm Migration Associated with Synoptic Weather Patterns

W.B. Showers

The report by Sherrod, Shaw, and Luckman (1979) that black cutworm, *Agrotis ipsilon* (Hufnagel), eggs are oviposited on weeds in fields before corn is planted and the findings by Showers, Kaster, and Mulder (1982) that emerging corn (coleoptile to one-leaf stage) will sustain the severest damage from a black cutworm attack strongly suggest that the black cutworm adult is present in the Corn Belt during the early spring (late March or early April). After Hill et al. (1979) identified and synthesized the black cutworm sex pheromone system, Levine et al. (1982) conducted an early-season detection experiment over a large area of the U.S. Corn Belt. They determined that, except in southern Missouri, male capture in pheromone-baited traps occurred approximately 20 nights before male capture in blacklight traps. These results indicated that black cutworm adult activity was occurring much earlier than previously detected. When the developmental rate of the black cutworm, using 10.4° C. as the base threshold temperature (Luckmann et al. 1976), was applied to the adult capture data of Levine et al. (1982), the degree-day accumulation suggested that overwintering black cutworms could not account for the early pheromone trap captures. These calculations were substantiated by the results of overwintering experiments conducted by Story and Keaster (1982). They determined that, in central Missouri, although adult moths emerged in field cages during September and deposited eggs, few of the eggs were viable. Those that were viable, however, died during late January; also, black cutworm larvae or pupae were not found during the winter. Further, Kaster and Showers (1982) presented data indicating that black cutworm adults immigrate to central Iowa each spring and that F_2 progeny of these adults enter a reproductive diapause during September (Figure 1).

Hypothesizing that immigration and reproductive diapause (Kaster and Showers, 1982) is part of the black cutworm phenology in the Corn Belt allows us to divide the season annually into the periods presented in Table 1.

The percent capture of black cutworm males in traps baited with synthetic sex pheromone shows that the capture in southern Louisiana is highest during the winter and lowest during the summer. The spring and autumn captures, however, are similar. In central Iowa, during a year of low black cutworm infestation (1980), the largest percent capture occurred during the summer. During 1981, however, a year of high infestation (DeWitt, 1981), 81.7 percent of the capture occurred during the spring (mid-March to mid-June). Other than January to mid-March, the lowest percent capture of black cutworm males in central Iowa occurred during the autumn, precisely while captures were on the increase in southern Louisiana (Table 1). The capture of black cutworm males in blacklight traps during the autumn, however, is usually as large or larger than the spring captures (Figure 1), suggesting that autumn flight activity is substantial.

These data (Figure 1 and Table 1) and the results of the studies of Kaster and Showers (1982) and Story and Keaster (1982) provide circumstantial evidence that black cutworms immigrate to the Corn Belt during the early spring and might not overwinter north of 38° north latitude. Another study presently being conducted is examining the relationship between weather patterns and captures of black cutworm males in traps baited with synthetic sex pheromone. Meteorological information gathered from the National Weather Service consists of wind trajectories and temperatures at 850 millibars (about 5,000 feet) and at surface (about 20 feet) and precipitation for 13 stations in the lower Midwest and 15 stations in the upper Midwest (Figure 2). The midsection of the United States was divided into lower and upper Midwest at roughly 38° north latitude.

Four pheromone-baited sticky traps were stationed beginning February 15, 1981, on the Iowa State University Research Farm, Ankeny, Iowa, about 800 meters apart; three were one meter above the surface and one was five meters above the surface. Meteorological data were collected beginning March 2, 1981. Wind trajectories similar to those presented in Figure 3 occurred six separate times for a total of 15 nights beginning March 26 and ending April 15, 1981. The average number of black cutworm males per night and the local temperature (50° F.), wind (5 to 20 miles per hour), and precipitation (none to mist) ratings required for flight are presented in Figure 4. The traps did not capture black cutworm males until the night of March 27, just after the initiation of the strong southerly winds presented in Figure 3. The local ratings for flight activity, however, were adequate (70 percent or higher) from 6:00 p.m. to midnight (early period) beginning March 10, 1981, and adequate both early and late (midnight to 6:00 a.m.) beginning March 21, 1981. Assuming that black cutworm pupae overwinter in central Iowa, the 460 degree days (Fahrenheit degree conversion from Luckmann et al. 1976) necessary for moth emergence would not accumulate until May 15, 1981. If, however, the adult (moth) black cutworm overwinters in central Iowa, then there should have been captures of males in the pheromone traps shortly after March 10, 1981, when local ratings for flight activity achieved 70 percent or higher (Figure 4).

These results present more circumstantial evidence that black cutworm adults might immigrate to northern Missouri and central Iowa from the Gulf Coast areas and, possibly, Mexico. A test to determine the technical feasibility of marking, releasing, and recapturing black cutworm adults will have to be conducted, however, to confirm these conclusions.

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Table 1. Number and Percentage of Adult Male Black Cutworms Captured in Two Traps, per Location, Baited with 75 μg Z 7-12:Ac and 25 μg Z 9-14:Ac (Showers, Robinson, and Keaster, Unpublished)

Phenology of black cutworm in the Corn Belt	Iowa		Louisiana	
	1980 (%)	1981 (%)	1980 (%)	1981 (%)
Pre-immigration period (Jan. to mid-March)	0 (0)	0 (0)	63 (39.9)	63 (67.7)
Immigration-infestation period (mid-March to mid-June)	177 (37.3)	1,096 (81.7)	48 (30.4)	15 (16.1)
Summer period (mid-June to Sept.)	294 (61.0)	244 (18.2)	9 (5.7)	1 (1.0)
Reproductive diapause period (September to late November)	4 (0.8)	1 (0.1)	38 (24.0)	14 (15.2)
Total	475 (100)	1,341 (100)	159 (100)	93 (100)

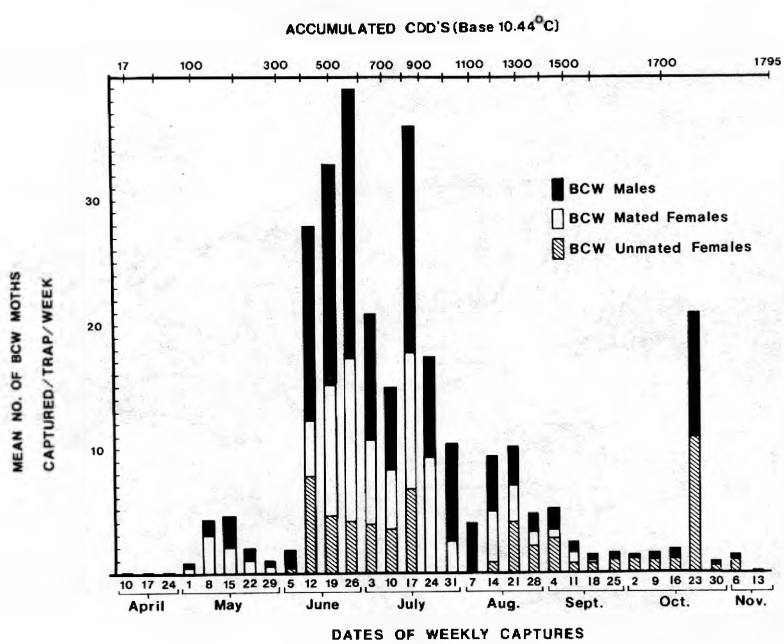

Figure 1. Weekly average number of black cutworm males, mated females, and unmated females captured in seven blacklight traps, Central Iowa, 1979.

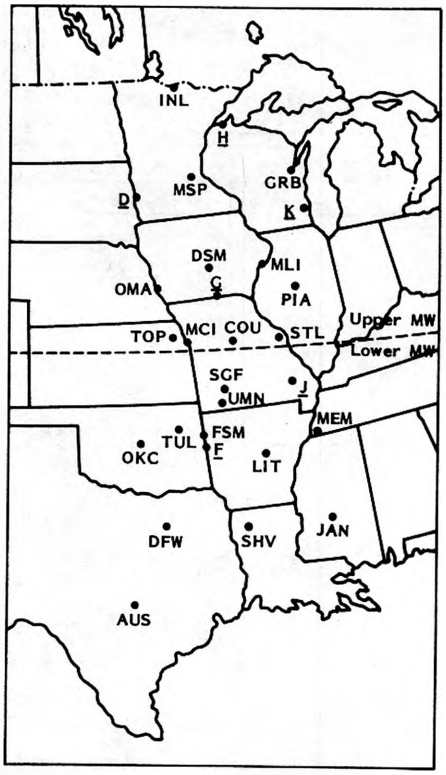

Figure 2. Weather stations used to rate meteorological factors in the upper and lower Midwest.

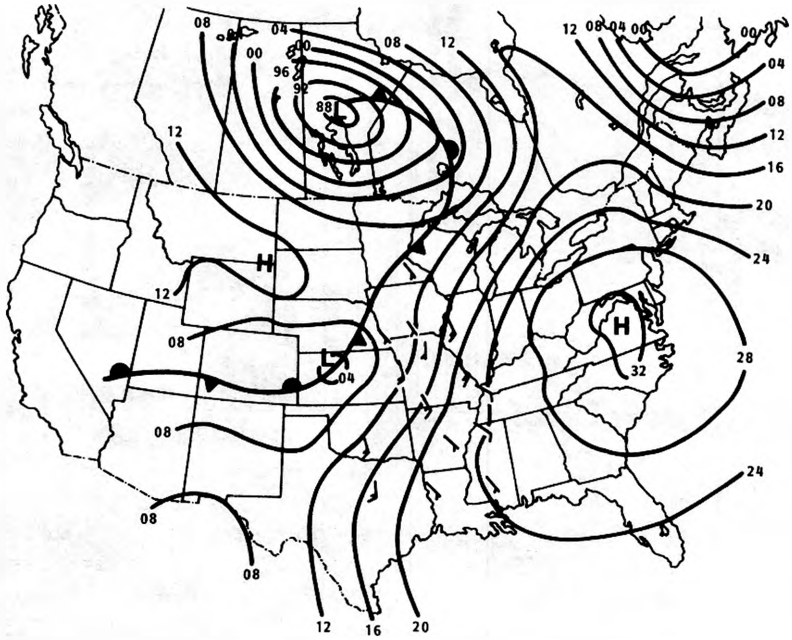

Figure 3. Synoptic weather pattern, including wind vectors, for 0600 CST, April 7, 1981.

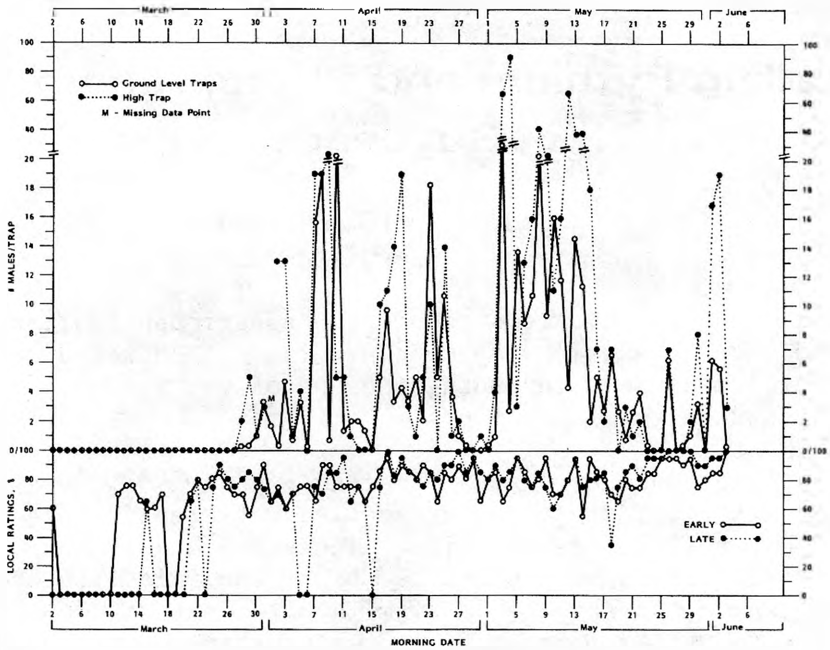

Figure 4. Climatological rates and average captures of black cutworm males in four pheromone-baited traps, Central Iowa, 1981 (Domino, Showers, and Taylor, unpublished).

Controlling Pythium and Phytophthora Fungi in Soybeans

H.W. Kirby

Controlling soybean root rot problems requires a conscious effort by the grower and the use of an integrated disease management program. Integrated management combines all available control measures, including the use of pesticides, crop rotation, resistant varieties, and cultural practices.

Both the Pythium species and *Phytophthora megasperma* var. *glycinea* belong to a group of fungi known as "water molds." They are called water molds because disease development is favored by water-saturated soils. The Phytophthora fungus, in particular, is more active during periods of wet weather since the infective spores of this fungus, the zoospores, have the ability to swim in water-saturated soils and actively seek out soybean roots. If soil pores are not water saturated, then no zoospore infection takes place and only limited infections occur from direct germination of oospores.

Both Phytophthora and Pythium can cause damage in soybean crops from planting through grain fill. Pythium usually causes major damage early in the season, shortly after the soybean seeds have been planted. This fungus will invade newly planted or germinated seed and cause a soft rot that is characterized by a dark brown or black discoloration of the seed or young seedling. Field damage will appear as large gaps in the rows.

Damping-off, also caused by species of Pythium, may kill newly emerged seedlings. The typical symptoms of damping-off are a dark brown to black discoloration of the hypocotyl (seedling stem) accompanied by a watery soft rot. Seedlings usually fall over and disintegrate when attacked by this fungus.

Phytophthora also may damage new plantings or emerging seedlings. This organism is usually most devastating, however, late in the season, when it attacks mature plants that have already set pods. The damping-off phase of this disease is very similar to that of the Pythium fungi. Plants either fail to emerge or have the typical darkened hypocotyl and later disappear, leaving gaps in the stand. Attacks on mature plants produce a chocolate-brown to black discoloration of the stem beginning at the soil line and continuing up the stem several nodes into the leaf stems (petioles). Leaves usually will turn light brown to buff and will droop, but they do not fall off the plant. The drooping leaves and the darkened stem are diagnostic symptoms for Phytophthora root rot.

Successful control of either Pythium or Phytophthora depends upon several management techniques. One major requirement is improved drainage in areas where either pest is a problem. Tiling or ditching to eliminate excessive soil moisture will help reduce zoospore infections.

Growers should also be certain that they are planting high-quality, disease-free seed. Such seed will have a cold germination of 70 to 80 percent or more.

Seed treatments are useful in protecting both susceptible and tolerant soybean varieties. These chemicals are inexpensive and will protect both the seed and the newly emerging seedlings from these diseases. Consider using seed treatments when you are planting seed that is known to have reduced germination due to fungal infection. (Seed treatments will not improve germination rates except where fungal infections occur.) Seed treatments also can be used when a seed crop is grown, when reduced seeding rates are used, or when conditions are such that germination will be slow and seeds will be exposed to soil organisms for an extended period of time.

Two new seed treatment fungicides, Apron (Ciba-Geigy) and Grandstand (Dow), have given good to excellent control of Phytophthora root rot. Both fungicides are systemic and appear to give best control when used in conjunction with tolerant varieties. Label clearance for Apron is expected in December 1982. Apron will be marketed by the Gustafson Company.

No soybean varieties are resistant to Pythium, and this disease must be managed using the other techniques already noted. A number of resistant or tolerant varieties can control Phytophthora root rot problems, however. Unfortunately, the resistant varieties are resistant only to a few selected races of the Phytophthora fungus. There are thought to be 2,048 races of this fungus in nature, although only a very few have been found in Illinois and surrounding states. Many of the current soybean varieties carry genes for resistance to multiple races. Growers should check with county Extension advisers or seed dealers for further information.

Tolerance offers an alternative to the use of resistant varieties. Tolerant varieties are not affected by any race and will yield well where Phytophthora is a problem. However, tolerance is not expressed until plants are out of the seedling stage. If tolerant varieties are selected, therefore, growers may wish to add a seed treatment to protect the emerging stand.

Growers can successfully control either of these fungal pests if a combination management approach is used. Improved drainage plus the use of pesticides, seed treatments where needed, and resistant and tolerant varieties will reduce losses early in the season and help preserve plants throughout the season.

Volunteer Corn Control in Soybeans

L.E. Paul

Volunteer corn in soybean fields has become more of a problem for farmers as they have changed management procedures and crop rotations. The problem varies each year, depending on the amount of ear and shelled corn that is left from the preceding corn crop. If this loss is kept to a minimum, the volunteer corn problem can be minimized. With the trend toward more corn-soybean rotations and less tillage, however, the problem of volunteer corn has been increasing.

Work has been done for three years at the Northern Illinois Agronomy Research Center near DeKalb on the effects of volunteer corn in soybeans and on methods to control it effectively. The 1980 and 1981 work was centered around the use of Roundup and Hoelon as control agents since they were the main products on the market recommended for volunteer corn control at the time.

Tillage equipment can play a large part in the control of volunteer corn. The use of a moldboard plow in the fall before the 1980 crop year reduced volunteer corn populations by approximately 90 percent. A fall chisel operation on other plots that same year reduced the volunteer corn population by approximately 80 percent. As farmers move toward more limited use of moldboard and chisel plows, however, they will need other methods of control.

The use of a dinitroaniline herbicide to control volunteer corn has sometimes been suggested. Some people suggest that corn will not set ears in fields treated with a dinitroanaline herbicide. In our 1982 work, the use of a dinitroanaline herbicide (Treflan) did lead to a corn population reduction and a corn yield reduction of 50 to 75 percent; in other years, reductions of up to 90 percent were found. In all plots and years, however, some plants were still able to set an ear and produce grain.

In 1982, some of the new compounds were tested at various rates to measure their effectiveness in reducing the volunteer corn problem. At all rates, with all herbicides tested, the volunteer corn population was reduced by 75 to 100 percent, and the corn grain yield was reduced by 80 to 100 percent. The soybean yield was increased from about six to twelve bushels per acre compared with the untreated check plot. The use of the herbicides paid returns of up to ten times the cost of treatment, and all chemical treatments would have more than paid for the cost of treatment.

Another benefit of all of the 1982 treatments was the reduction of the volunteer corn population to below the level that would necessitate soil rootworm insecticide treatment if the field was planted to corn in 1983. The untreated check had almost 5,000 plants per acre, the population entomologists are using to determine treatment or nontreatment for rootworm control in the following year. The check would probably justify treatment if the field were to be planted to corn in 1983.

Another benefit of volunteer corn control is the elimination of foreign material (corn) and excess moisture from the harvested soybeans. Probably the only plots that would have had a foreign material dock would have been the plots with the low rate of Poast, the Treflan-treated plots, and the untreated checks.

The data in the following table indicate that early removal of volunteer corn is likely to lead to improved soybean yields.

Herbicides for Control of Volunteer Corn in Soybeans, 1982

Treatment[a]	Pounds of active ingredient per acre	Soybeans Yield (bushels per acre)	Corn Yield (bushels per acre)	Corn Population	Corn Ear and nubbin population
Poast & Crop Oil Concentrate (COC)[b]	1/8	32.5	8.09	1,424	1,978
Poast & COC	1/4	37.7	0.51	180	221
Fusilade & COC	1/16	37.0	0.46	270	166
Fusilade & COC	1/8	33.2	0.23	55	55
CGA 82725 & COC	1/16	38.0	0.64	207	194
CGA 82725 & COC	1/8	33.8	1.08	166	249
CGA 82725 & COC	1/4	36.1	0.04	28	14
Dowco 453 & COC	1/16	38.4	0.16	14	28
Dowco 453 & COC	1/8	35.0	0	0	0
Hoelon (broadcast)	1	34.8	0.49	37	138
Hoelon (spot spray)	10 ml/quart	34.8	0.47	97	125
Round-up rope wick (one way)	2:1 H_2O:round-up	31.8	0.06	235	138
Round-up (spot spray)	1% solution 10 ml/quart	34.3	0.75	152	221
Untreated check		26.1	40.07	4,772	7,372
Weed-free check (hand hoe)		35.7	0.84	346	332
Treflan (preplant incorporated)	1	32.24	10.14	2,448	2,416

[a]All plots were treated with three pints Dual (preplant incorporated).
[b]Crop Oil Concentrate (COC) was applied at one quart per acre when used.

The Japanese Beetle Problem in Illinois

D.E. Kuhlman and S.P. Briggs

Japanese beetles (*Popillia japonica* Newman) have been very abundant during the past three years in many fields of corn and soybeans in Iroquois County in east central Illinois. The primary problem area is about 20 by 30 miles in the northeastern part of Iroquois County.

During the past 10 years, Japanese beetles have gradually spread and increased. Adults have been abundant enough in some fields of corn and soybeans in Kankakee, Vermilion, and Champaign counties to prompt inquiries from farmers about control. Although records are not available, the Japanese beetle can probably be found in most counties in Illinois.

The Japanese beetle is a relatively new pest in Illinois. In 1953, a large infestation of Japanese beetles was found along the Illinois-Indiana border near Sheldon, Illinois, in Iroquois County. A survey that year showed that 10,000 acres of crops, primarily corn and soybeans, were infested (Luckmann and Decker, 1960). A control program to slow the spread of this pest was begun in 1954 by the Plant Pest Control Division, Agricultural Research Service, USDA, and the Illinois Department of Agriculture. A block of 1,535 heavily infested acres received a broadcast treatment of dieldrin.

By 1958, Japanese beetles were found on approximately 50,000 acres of farmland in eastern Iroquois County, and dieldrin treatments had been applied to 17,844 acres to suppress this new invader. The dieldrin treatment gave excellent control of Japanese beetle larvae in the control program. Eradication treatments for the Japanese beetle are no longer being used in Illinois. The last applications for suppression were applied in 1966 to 8,000 acres in St. Clair and Madison counties.

All areas in Illinois that were previously regulated by the USDA are now listed as "generally infested." Basically, articles from "generally infested" areas that are regulated for interstate movement include soil, plants with roots, and grass sod. Persons desiring more information on regulations for the Japanese beetle should contact the Illinois Department of Agriculture.

Description, Life Cycle, and Damage

The adult Japanese beetle is shiny, metallic green, about 1/2 inch long, with bronze-colored wing covers. It has two tufts of white hair on the tip of its abdomen and five tufts along each side of its body under the edges of the wings. The fully grown larva is about one inch long and C-shaped. It can be distinguished from other grubs by a V-shaped arrangement of two rows of spines on the underside of the last abdominal segment.

There is one generation per year. The Japanese beetle overwinters as a fully grown larva in the soil and pupates in the spring. The adults commence emerging in early July. Eggs are laid in the soil in fields of corn and soybeans during July and

August and soon hatch. The grubs feed on the roots of grasses. The greatest beetle activity lasts about four to six weeks. Most are gone by mid-August.

The adults are known to feed on more than 250 species of plants, including corn silks, soybeans, smartweed, grapes, flowers, and ornamentals of all kinds. The primary damage to corn occurs during the period of pollination, when the beetles clip silks and interfere with pollination. Later, the beetles may feed on the developing kernels at the ear tips. The adults also feed on the leaves of soybeans, chewing out the tissue between the veins and leaving a lacelike skeleton. The adults prefer to feed on plants exposed to the direct rays of the sun.

The grub stage of the Japanese beetle feeds on a variety of garden and truck crops, ornamental plants, and grasses. However, Japanese beetle larvae rarely cause economic damage to the roots of corn and soybeans. We have observed populations of six per square foot without apparent injury to the roots of corn.

Japanese beetles spread primarily by flying. The normal life span of the beetle is 30 to 45 days. The Japanese beetle is a gregarious insect. Typically, masses of the beetle will collect on the ear tip or on the leaves of soybeans. A female attracts many males to a plant. Enormous populations may build up on some plants, while others are only lightly infested. The female beetle tends to deposit her eggs in the vicinity of the plant upon which she is feeding. Field observations indicate that the adults lay eggs in both corn and soybeans. The presence of smartweed, a favorite host, may increase the number of eggs deposited in a field.

Economic Threshold

Corn

Because the grub stage of the Japanese beetle rarely feeds on the roots of corn, a soil insecticide is not warranted at planting. The use of a soil insecticide to control the grubs, with the intent of reducing the adult population, does not appear to be a practical solution to reducing Japanese beetle populations. Although Lorsban, Amaze, and Counter are labeled to control grubs in corn, research conducted by Briggs and Kuhlman (1981) indicates that the products will only give about 20 to 60 percent control.

Tests conducted during 1982 with no, three, five, and ten beetles caged per ear tip at silk emergence were inconclusive in determining the number required to affect pollination. Ten beetles per ear tip did not reduce ear weight. It should be pointed out, however, that the beetles remained caged on the ear tips for only five days (Table 1). As a guide, consider treatment when there are five or more beetles per ear tip and pollination is not complete.

A key element in determining the need to prevent pollination damage by Japanese beetles in field corn is the stage of plant development. If silks are brown and pollination complete, treatment will not be necessary, unless the beetles continue to feed on the kernels at the tip of the ears.

Soybeans

Because the grub stage of the Japanese beetle does not feed on the roots of soybean plants, soil insecticides are not warranted at planting. However, heavy infestations of adults feeding on the foliage of soybeans during July and August may require treatment. See Table 2 for decision-making guidelines for the control of Japanese beetles in soybeans.

Table 1. Pollination Damage by Japanese Beetles to Corn in Early Silk, Urbana, 1982

Number of beetles per ear[a]	Damage rating[b]	Average ear weight in grams per ear
0	0	154
3	1.8	175
5	2.1	167
10	3.4	160

[a]Beetles were caged on ears just as silks were emerging and left on plant from July 20 to 25, 1982.
[b]Rating scale: 0 = no damage; 1 = a few strands of silk were cut; 2 = over one-half of silks per ear were cut to one to two inches; 3 = most silks on ear were cut to one inch or less; 4= all silks were cut back to husk.

Table 2. Decision-making Guidelines for Control of Japanese Beetles on Soybeans after Full Bloom and before Seed Maturation (R1 to R5)

Percent defoliation	Number of adults per foot of row: Less than 12	12 to 18	More than 18
0-20	Sample again in 7 days	Sample again in 3 to 5 days	Spray
20-30	Sample again in 3 to 5 days	Spray	Spray (overdue); probability of minor loss
over 30	Probability of loss, but population is declining	Spray (overdue); some loss has occurred	Spray (overdue); significant loss

Developed by Dr. Marcos Kogan, research entomologist with the Illinois Natural History Survey and University of Illinois.

Control

The high populations of Japanese beetles in localized areas have raised a number of questions regarding insecticide control methods and the feasibility of various control alternatives. Following are some of the questions that have been raised about the control of the adult and larval stages of the Japanese beetle.

1. How feasible is grub control in corn and soybeans?

Answer: Because most Japanese beetle grubs are fully grown in the fall, they rarely damage the roots of corn or soybeans the following spring. A soil insecticide applied at planting with the intention of controlling the larval stage and thereby reducing subsequent beetle populations is not a practical approach. Soil insecticides registered for grubs only give about 50 percent control. A further complication is that adults deposit eggs in noncrop areas, as well as in corn and soybeans. Hence, it would be necessary to treat all these areas with a soil insecticide to have any notable impact on overall larval and adult populations. Likewise, foliar application of carbaryl, though effective in controlling beetles, would likely need to be applied over a large area perhaps two or more times per season to make a significant impact on overall populations.

2. Will applications of milky disease spores (*Bacillus popilliae*) provide effective control of the grub stage of the Japanese beetle?

Answer: Treatment of soil with milky disease spores has provided reasonably effective control of Japanese beetle grubs in turf areas in the middle Atlantic states. The milky spore disease kills grubs after causing their normally clear blood to become milky in appearance. The milky disease spores live in the soil for long periods, ready to infect and kill successive broods of Japanese beetle grubs. Assays of soil in six eastern states and the District of Columbia during 1960 to 1963 showed that *Bacillus popilliae* was well established in only about one-third of the sample sites (Fleming, 1968).

The use of milky spore disease (trade names, Doom and Japidemic) to control the grub stage of the Japanese beetle does not appear to be practical for corn and soybeans. The initial investment of treating cropland with spores of *Bacillus popilliae* will range from $200 to $300 per acre. The effectiveness of *B. popilliae* spores for larval control depends, in part, on a relatively stable soil surface. Tillage operations decrease the effectiveness of the milky spore disease.

3. How effective are traps in controlling Japanese beetle adults?

Answer: Several traps are commercially available that are very effective in attracting and trapping the Japanese beetle. Most traps consist of a female sex pheromone and a floral lure containing eugenol and phenylethyl propionate, which are extremely attractive to the adults. The retail cost per trap is $10 to $11. Researchers have found that one or more traps per acre will capture about one-third of the beetles (Fleming, 1976). In general, traps are of little value in protecting plants from injury, although they may give one the feeling of satisfaction by virtue of the fact that thousands of beetles may be collected. While traps may be a useful tool to monitor Japanese beetle populations, they appear to be of little value as a means of providing adequate control.

Summary

The Japanese beetle is present in large numbers in Iroquois County and in isolated areas of surrounding counties in east central Illinois. High infestations are likely to appear in isolated areas in central Illinois in coming years, although the westward movement will not be rapid. The larval stage of the Japanese beetle does not cause economic damage to the roots of corn or soybeans. However, the adults are voracious feeders and at times defoliate soybeans and cut silks and interfere with pollination of corn. The control of the Japanese beetle by means of soil insecticides, traps, and milky spore treatments is not economically feasible in corn and soybeans. Likewise, the wide-area sprays with dieldrin or carbaryl that were sponsored by the USDA to suppress the insect in 1954 and 1966 are no longer being applied in Illinois, nor are they likely to be.

Currently, the best alternative for coping with outbreaks of the Japanese beetle is to scout fields of corn and soybeans in the problem counties during July. The economic thresholds outlined in the preceding section will help growers determine the need for treatment.

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Integrated Pest Management Practices, Crop Rotation, and Tillage Effects on Grain Yields and Pest Populations*

L.M. Wax, M. Kogan, D. Kuhlman, S.M. Lim, and J.B. Schoper

The rise to prominence of the soybean crop in the Corn Belt during the past few decades has been accompanied by a more restricted crop rotation system that has increased the ease with which some pests can survive and spread. At the same time, there has been a steady increase in reduced tillage, which decreases soil loss but also favors the buildup of many pests. Chemical pesticides are one method of controlling pest problems, but indiscriminate use of pesticides can harm the environment as well as cause a genetic change in pests, thereby rendering the chemical useless. New techniques of integrated pest management are thus needed so that all control measures can be combined into a system most effective for a given problem. When the expertise of several pest-related scientific disciplines is combined, sound data can be collected to make intelligent pest management decisions. An integrated pest management system will thus consider disease, insect, and weed pests simultaneously while attempting to maximize returns for the farmer.

Crop Rotation/Tillage/Pest Management Study

Experimental plots were established in Illinois in 1979 at DeKalb, Urbana, and Dixon Springs with the following objectives: (1) To test the hypothesis that the populations and control of disease, insect, and weed pests will differ when soybeans and corn are grown (a) in different cropping sequences, (b) under conventional versus reduced tillage, (c) with different levels of pest management, and (d) in different geographic locations; (2) to determine if cropping sequences, tillage, level of pest management, and location interact to affect pest populations and control; (3) to correlate the pest assessment data obtained in objectives one and two with yield losses; (4) to develop empirical models to estimate yield losses caused by disease, insect, and weed pests; and (5) to evaluate by economic analysis the crop rotation, tillage, and pest management systems studies.

The crop rotations at all three locations consist of continuous corn, continuous soybeans, and a corn-soybean rotation, with only the Dixon Springs studies containing a fourth rotation. The fourth rotation at Dixon Springs involves a two year rotation of corn followed by winter wheat and double-crop soybeans.

The tillage systems used differ somewhat among locations. At each location, conventional and reduced tillage systems are used. Conventional tillage on corn involves either a chopping or disking operation followed by the use of a moldboard

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plow in the fall and at least two passes with a secondary tillage tool in the spring. Conventional soybean ground is chisel plowed in the fall, with at least two passes with a secondary tillage tool in the spring.

Before fall, 1981, the reduced tillage systems used at DeKalb and Urbana were essentially the same. Corn plots were disked or the stalks were chopped; the plots then were chisel plowed in the fall, and two secondary tillage operations were performed in the spring. Soybean plots under a reduced system differed in that no fall tillage was performed. Concern was expressed during the 1981 growing season that our reduced tillage system in corn did not leave enough plant residue on the soil surface. Therefore, in the fall of 1981 and 1982, a soil saver (combination tool that involves both disks and chisels) was used on the reduced tillage corn plots at Urbana, and no fall tillage was used at DeKalb on the reduced tillage corn. At least two passes of a secondary tillage tool are being used in the spring on these plots. The reduced tillage system used at Dixon Springs is completely no-till and is representative of common practices in that area of the state.

Finally, three levels of pest management--termed low, medium, and high--are imposed on these combinations of rotation and tillage systems. These levels are differentiated from one another by applying (or not applying) various herbicides, soil insecticides, foliar insecticides, and foliar-fungicides, often varying the rates or the number of applications. A generalized summary of pest management treatments is given in Table 1.

Aside from numerous chemical and cultural treatments for pest control, extensive monitoring of all crop pests occurs throughout the growing season. A schedule of the pest monitoring is shown in Table 2.

Results

Because of the extensive monitoring of all crop pests throughout each growing season, a large amount of data is accumulated each year. Therefore, only selected information from the 1982 growing season is included to illustrate some of the trends and differences being observed.

Weed Control

Weed control differences are becoming quite noticeable in the plots at all three locations. Table 3 contains the 1982 ratings for late season weed control.

Dixon Springs and Urbana both had more weed problems than DeKalb. Pest management levels had the largest effect on weed control across all three locations. Tillage and crop rotation effects are also apparent. The low and medium management levels on reduced tillage or no-till plots result in consistently poorer weed control than do the low and medium management levels on conventional tillage plots. The continuous soybean plots generally have poorer weed control ratings than the rotated plots.

Disease Control

Differences in disease control are also being detected. Table 4 contains the percent severity rating for brown spot on the DeKalb soybeans at the R-6 maturity stage. The percent severity rating is approximately the percent leaf area infected. There is a pronounced pest management effect. Some tillage and crop rotation effects also seem to be showing up early in the season as the residue-borne diseases move onto the plants. Other soybean diseases detected and rated at one or more of the three locations include downy mildew, brown stem rot, charcoal rot, bacterial blight, and bacterial pustule. Some of the more important corn diseases detected and rated at one or more of the three locations include southern and northern corn leaf blight, rust, anthracnose, leaf spot, and various stalk rots.

Insect Control

Table 5 contains the root ratings for rootworm damage at Urbana. Urbana had more feeding than DeKalb, and the continuous-corn, low-management plots had the most rootworm damage. The reduced-tillage, low-management, continuous-corn plots also had poorer ratings than the conventional-tillage, low-management, continuous-corn plots. Other corn insects present in significant numbers at one or more of the three locations included cutworms, first and second generation European corn borer, and corn leaf aphids.

The soybean insect pressure at all three locations was light in 1982. The only insect population large enough to possibly affect yield was the green stinkbug population on the double-crop soybeans at Dixon Springs. Table 6 contains the total number of stinkbugs per 40 sweeps in each medium-pest-management, double-crop soybean plot. Based on this scouting, Orthene treatments were made to all of the medium-pest-management, double-crop soybean plots as well as to the high-pest-management, double-crop soybean plots. Therefore, we may detect some yield differences due to the different levels of soybean insect pest management on the double-crop soybeans at Dixon Springs.

Summary

The expertise of several pest-related scientific disciplines is being combined to evaluate different pest management systems. The simultaneous monitoring of disease, insect, and weed pests should show trends as to how pest management levels, cropping systems, and tillage systems affect pest populations and grain yields. Therefore, this monitoring should also allow more intelligent pest management decisions.

Data were presented from 1982 indicating some of the trends apparent during the growing season. Much more data was collected in 1982 and is being analyzed. Data from previous years have also been analyzed, and comparisons across years will be made at the end of the study.

Table 1. Pest Management Treatments Applied at the Low, Medium, and High Levels of Pest Management

Pest management level	Treatments applied
Low	One to two herbicide treatments No soil insecticide
Medium	One to three herbicide treatments One foliar fungicide treatment on the soybeans 1X rate of soil insecticide on corn
High	Three to five herbicide treatments Three foliar fungicide treatments on the soybeans Hand weeding Two foliar insecticide treatments on the soybeans Soil insecticide at 2X rate on all plots One foliar insecticide treatment on the corn

Table 2. Schedule of the Pests Monitored

May	June	July	August	September	October	November
Weed counts and ratings				Weed counts and ratings		
		-------Rated diseases on all plots every two weeks		-------------	Stalk rot ratings	
	Soybean insect survey		Soybean insect survey	Soybean insect survey	Soybean pod samples to check for insect feeding	
Cutworm surveys	1st generation corn borer surveys	Root ratings for rootworm damage Rootworm beetle surveys Corn leaf aphid surveys	2nd generation corn borer surveys		Final 2nd generation corn borer survey	Collect corn rootworm egg samples on all plots at DeKalb and Urbana after harvest
			Nematode sampling			

Table 3. Late-Season Weed Control Ratings for the Soybeans, 1982

Tillage system	Crop rotation	Pest management level	Late-season weed control rating[a]		
			Dekalb	Urbana	Dixon Springs
Conventional	Continuous soybeans	Low	45	12	38
		Medium	82	33	48
		High	98	99	98
	Soybeans after corn	Low	90	83	65
		Medium	94	87	87
		High	99	99	99
Reduced or no-till	Continuous soybeans	Low	10	32	8
		Medium	75	30	65
		High	98	98	98
	Soybeans after corn	Low	77	63	41
		Medium	77	73	49
		High	98	98	96

[a]Percentage of space between the soil surface and the crop canopy that is covered with a weed canopy. 0 = full weed canopy over whole plot at or higher than crop canopy height in soybeans; 50 = 50 percent of plot has weed canopy at crop canopy height or full canopy weeds where weed canopy height is one-half the crop canopy height; 100 = no weeds in whole plot.

Table 4. Dekalb Soybean Brown Spot Ratings at Soybean Maturity Stage R-6, 1982

Tillage system	Crop rotation	Pest management level	Brown spot percent severity[a]
Conventional	Continuous soybeans	Low	40
		Medium	20
		High	10
	Soybeans after corn	Low	40
		Medium	19
		High	9
Reduced	Continuous soybeans	Low	42
		Medium	19
		High	11
	Soybeans after corn	Low	44
		Medium	16
		High	9

[a]Percent severity is the percent leaf area infected.

Table 5. Dekalb and Urbana Corn Root Ratings for Rootworm Feeding, 1982

Tillage system	Crop rotation	Pest management level	Root rating[a]	
			Dekalb	Urbana
Conventional	Continuous corn	Low	1.6	3.9
		Medium	1.2	1.8
		High	1.2	1.7
	Corn after soybeans	Low	1.3	1.7
		Medium	1.1	1.1
		High	1.2	1.3
Reduced	Continuous corn	Low	2.9	4.2
		Medium	1.3	1.6
		High	1.1	1.4
	Corn after soybeans	Low	1.4	2.0
		Medium	1.1	1.3
		High	1.1	1.2

[a]1 = no visible damage or a few minor feeding scars on the roots; 6 = three or more nodes of roots completely destroyed.

Table 6. Number of Stinkbugs per 40 Sweeps in the Dixon Springs, Medium Pest Management, Double-Crop Soybeans, 1982

Tillage system	Replication	Number of stinkbugs per 40 sweeps
Conventional	1	7
	2	10
	3	21
No-till	1	2
	2	10
	3	32

New Developments in Spray Nozzles and Related Equipment

S.L. Pearson and L.E. Bode

The agricultural chemical industry has recognized the need for improving the quality and precision of pesticide application, and several new developments in application systems have recently occurred. Despite these new developments, most of the equipment used to apply pesticides has not kept pace with the new era of pesticide technology. Many of the modern pesticides presently being introduced are highly selective and are effective at very low rates of application, but the equipment used to apply these chemicals still uses the same basic principles of atomization and operation as when synthetic pesticides were first widely used over 30 years ago. The equipment has been highly refined, however, and the new developments should allow more efficient application.

Delavan Corporation has recently introduced color-coded thermoplastic (Zytel) nozzle tips. Each size tip is molded in a different color so that it is easy to verify that only one size is mounted on a spray boom. Initial reports indicate that the tips are economical and result in consistent spray patterns and that their resistance to wear compares with that of stainless steel nozzles. We are currently conducting wear and pattern tests on the new Zytel nozzle tips.

Both Delavan Corporation and Spraying Systems Company have introduced new thermoplastic nozzle bodies and caps. These fittings include easy snap-on, snap-off, self-aligning caps. An entire boom can be fitted with a set of nozzles in only a few minutes. The problems of nozzles leaking due to overtightening and crossthreading are eliminated when the new quickly connected nozzles are used, but rubber seals are required with these nozzles.

Nylon nozzle tips having ceramic inserts are available through Westgo. Ceramic provides better wear resistance than other materials, but no data are available regarding the wear resistance of these new nozzles.

Advances in electronics are having an impact on pesticide application techniques. Several companies manufacture monitors that continuously display the spray rate during application. Some have a microprocessor-controlled servo-valve assembly that automatically regulates the flow in proportion to the travel speed to maintain a constant spray rate. Several systems have special features such as clogged-nozzle alarm systems, manual overrides, and individual boom controls. Sonar has been adapted to gauge travel speed and to adjust automatically the height of the boom as the sprayer moves through the field.

Tests of intermittent sprayers using mechanical feelers or photoelectric sensors have shown that shutting off the spray between each plant reduces the pesticide amount by 25 to 80 percent with no loss of pest control. Many other devicies for selective application of pesticides have become available during the past few years, including directed nozzles, shielded nozzles, wax bars, foam-rubber wipers, recirculating sprayers, and roller and rope-wick applicators. Shielded air-blast and air-cushion sprayers are being studied as a way to obtain good plant coverage with spray mists while protecting the environment from drift damage.

Hypro has introduced a series of diaphragm pumps that can handle the many tank-mix formulations, fertilizer suspensions, and slurries as well as the standard pesticide formulations. The diaphragm pumps are capable of developing maximum pressures ranging from 200 to 850 pounds per square inch with maximum outputs ranging from 5 to 60 gallons per minutes.

Among custom spray operators, there is interest in using solid-stream nozzles to apply fertilizer in concentrated strips (bands). The verdict is still out on the claims for increased yields with this type of application. Most commercial operators presently apply herbicides with fluid fertilizer. With this type of applicator, however, combined applications are not practical. There is also interest in attaching a tool bar behind a floater and "knifing in" suspension fertilizer. In some situations, these options may be a way for an operator to expand his sales. When attaching any tillage equipment to a floater, you must take into consideration the power requirements, the increased stress on the power train, and a lower speed of application.

All of these new developments have positive and negative aspects, but for the most part they are attempts at improving the application of pesticides and fertilizers. It is encouraging to see that these attempts are being made.

Damage, Economic Thresholds, and Control of Potato Leafhoppers in Alfalfa

K.L. Steffey

Proper management of the potato leafhopper is one of the keys to good alfalfa yields in Illinois. The leafhoppers and the damage they cause often go unnoticed because the insect is small and early symptoms of injury are subtle. However, when potato leafhoppers occur in large numbers, alfalfa quantity and quality may be drastically reduced.

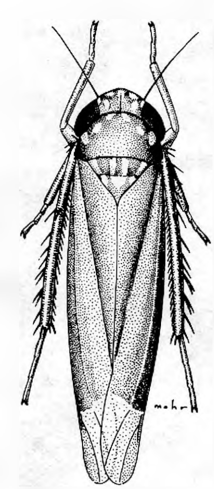
Potato leafhoppers are carried into Illinois each spring on prevailing winds from the Gulf Coast states. During the summers of 1981 and 1982 the numerous storm fronts that passed through the Midwest carried many migrant leafhoppers. The leafhoppers dispersed to alfalfa fields throughout Illinois, and their numbers increased rapidly over the summer. Many alfalfa fields were severely damaged, and approximately 16 percent of the alfalfa acreage in Illinois was sprayed for leafhopper control in 1981 and 1982.

Alfalfa growers in Illinois are becoming more aware of the potato leafhopper as a potential threat to alfalfa production. More people are monitoring alfalfa fields throughout the growing season, and the scouts are detecting when the leafhoppers reach economic levels. Both awareness of the problem and the large populations of leafhoppers in 1981 and 1982 account for the increased percentage of alfalfa acreage treated for leafhopper control.

This paper includes information about the biology and behavior of potato leafhoppers. Current scouting techniques, economic thresholds, and management practices are reviewed. An ongoing research project is also discussed.

Description and Biology

The adult potato leafhoppper is a winged, green, wedge-shaped insect about 1/8 inch long. The nymph, or immature leafhopper, resembles the adult except it is smaller, yellow-green, and wingless. Both the adults and the nymphs are very active. The adults fly or jump when they are disturbed, but the nymph characteristically moves sideways very rapidly.



Adult potato leafhopper, enlarged 17 times.

Potato leafhoppers cannot survive the harsh winters in Illinois. They reproduce continuously throughout the winter months in the Gulf Coast states. When their southern legume hosts are cut, plowed, or become dry in April, the leafhoppers disperse readily. The airborne leafhoppers are then carried northward by prevailing currents of warm wind.

Potato leafhoppers are first found in alfalfa fields in Illinois during May and early June. However, their time of arrival varies each year depending on weather patterns. They usually arrive too late to damage the first crop of alfalfa, but their numbers may increase rapidly to economic thresholds in June and July. Leafhopper populations begin declining in August, although some leafhoppers can be found until the first killing frost.

As soon as they arrive in alfalfa fields, adult potato leafhoppers begin mating. The females insert their eggs into the stems and large leaf veins. Each female lays about three eggs per day over six to eight weeks. The eggs hatch in six to nine days depending on the temperature. The leafhoppers go through five nymphal instars in about two weeks before they transform to adults. The life cycle from egg to adult takes approximately three weeks. Because the life cycle is short and females lay eggs for six to eight weeks, there is a continuous overlap of generations.

Feeding and Damage

Both the nymphs and adults use their needle-like, piercing-sucking mouthparts to suck plant juices. The nymphs are the most damaging to the plants. The leafhoppers usually feed on the undersides of the leaflets and on the petioles. They insert their mouthparts and inject saliva, which has a toxic effect on the plants. Their mouthparts also distort and block the tiny tubes that distribute nutrients within the plant.

The initial symptom of leafhopper damage to alfalfa is a characteristic V-shaped yellowing at the tips of the leaflets called "tipburn" or "hopperburn." As the damage progresses, the leaves turn completely yellow and may turn purple or brown and die. Extensive feeding by the leafhoppers causes the internodes to stop growing, and injured plants are stunted and bushy. Severely damaged fields appear both yellow and stunted.

Feeding injury caused by potato leafhoppers reduces plant growth and stand vigor. As a result, alfalfa yields and the longevity of stands are reduced. Damaged alfalfa plants do not recover as quickly after a cutting has been made, so damage to one cutting may affect the yield of the next cutting or even the next year. Leafhoppers deplete the carbohydrate reserves in the root systems, so the plants are less hardy and may not survive the winter.

Alfalfa plants damaged by potato leafhoppers produce more sugar and less protein and carotene. Thus, the nutritional value of the hay as feed for livestock is reduced. This reduction in hay quality is less obvious than yield reduction, but it may be even more important economically in the long run.

Very young plants (new seedings) and plants very early in the stages of regrowth after a cutting are the most sensitive to leafhopper damage. Damage is intensified by moisture stress during a drought. Damage in individual fields is more severe in dry areas and along field edges.

Diagnosis of potato leafhopper injury is sometimes difficult because the damage resembles boron deficiency. However, boron deficiency is usually restricted to younger leaves, while leafhopper damage is observed on older leaves. In addition, the presence of the insect is often the key to diagnosing the problem.

Scouting and Economic Thresholds

Monitoring for potato leafhoppers in alfalfa should begin around the time the first cutting is being made. Peak leafhopper populations occur between early June and mid-August. Scouting should continue at regular intervals throughout the summer. However, more frequent scouting is critical when the alfalfa is regrowing after a cutting.

A 15-inch diameter sweep net is currently the best and only tool for monitoring potato leafhopper populations in alfalfa. As a general rule, a set of 50 sweeps in each of five areas in the field provides a representative sample in alfalfa less than four inches tall. Reduce the sample to 20 sweeps per area if the alfalfa is more than four inches tall.

A single sweep consists of swinging the net like a pendulum down into the alfalfa (4 to 6 inches into the foliage) from side to side as you walk. When you complete a set of sweeps, swing the net a couple of times in the air to move the insects to the bottom of the net. Slowly invert the net to count both the nymphs and adults.

Treatment decisions should be based on the average number of leafhoppers per sweep of the net and the height of the alfalfa. Determine the average number of leafhopppers per sweep by dividing the total number of leafhoppers by the total number of sweeps. Determine the height of the alfalfa by collecting 10 stems each in the five areas, measuring the stems, and using the average as an estimate of crop height.

Because potato leafhoppers cause more injury to regrowing alfalfa than to taller, more mature alfalfa, the economic thresholds vary accordingly (Table 1). As crop height increases, the number of leafhoppers necessary to cause economic damage also increases.

Early detection of a potential leafhopper problem is essential. Loss occurs quickly to new growth even before symptoms are apparent. Loss that has already occurred is not recoverable, but further damage may be prevented if leafhoppers are controlled after the symptoms of damage appear.

Leafhopper Management

An insecticide spray is the only effective method of controlling potato leafhoppers after their numbers exceed the economic threshold. The maximum benefit to alfalfa can be achieved by spraying four or five days after cutting if leafhopper numbers are at damaging levels. Because of the short residual activity of most insecticides and the rapid growth of alfalfa, an insecticide will protect only the cutting to which it is applied.

Several insecticides are registered for potato leafhopper control in alfalfa. The recommended insecticides are listed in University of Illinois Circular 899, *Insect Pest Management Guide - Field and Forage Crops* (see the insect recommendations section at the back of the manual).

Other practices that may aid in the management of potato leafhoppers involve planting and harvesting. Early planting minimizes leafhopper damage to spring-seeded alfalfa. When the average number of potato leafhoppers exceeds the economic threshold on alfalfa that is taller than 12 inches, an insecticide treatment can be avoided by cutting early if the yield will not be affected. However, a stubble spray may be necessary. Finally, good agronomic practices that promote vigorous plant growth will minimize the damage caused by leafhoppers.

Proper management of potato leafhoppers results in increased plant growth, vigorous regrowth after cutting, improved winter hardiness, better yields, and improved quality. Growers who wish to optimize their yields should include leafhopper management in their overall alfalfa management program.

Leafhopper Population Study

An experiment was designed to study the effects of potato leafhopper damage on alfalfa quality and yield in Illinois during 1981 and 1982. The plots were located in a Dairy Science field at the University of Illinois in Urbana. Extension entomologists cooperated with Ed Armbrust, Bill Lamp, and Steve Roberts of the Illinois Natural History Survey during the design and evaluation of the plots. The study was conducted during 1981 and 1982, but only the 1981 data are presented. The 1982 data were confounded by large populations of plant bugs.

Different population levels of leafhoppers were established by spraying four different rates of methoxychlor and leaving one set of plots untreated. The five treatments consisted of 1.5, 0.25, 0.13, and 0.06 pounds of actual methoxychlor per acre and an untreated check. The treatments were arranged in a randomized, complete-block design and replicated four times. Individual plots were 100 by 100 feet.

The leafhopper populations were sampled before the treatments were applied, and one, seven, and fourteen days after treatment. The plant parameters measured at harvest were the height of 50 stems in each plot, the maturity of the stems, yield, and the percent crude protein. The heights of 50 stems per plot were measured one week after harvest.

Table 2 shows that different population levels were established by the different treatments. The differences remained throughout the two-week period. The plant parameters that were measured are presented in Table 3. The difference between the largest and smallest yields was 0.13 ton per acre, but the difference was not significant. However, both the percent crude protein and the stem length correlated well with different population levels of leafhoppers. As potato leafhopper numbers were reduced by increasing rates of methoxychlor, the percent crude protein and the stem length increased. The differential in stem lengths remained significant one week after harvest.

The results from this study reveal that control of damaging levels of potato leafhoppers improves both alfalfa growth and nutritional quality. Although the yield was not dramatically affected by the leafhoppers, the slow regrowth one week after harvest suggests that leafhopper damage may have long-term effects.

Table 1. Economic Thresholds for Potato Leafhoppers in Alfalfa

Average height of alfalfa (inches)	Average number of potato leafhoppers per sweep
Less than 3	0.2
3-6	0.5
6-12	1.0
More than 12	2.0

Table 2. Average Number of Potato Leafhoppers in Plots Treated with Different Rates of Methoxychlor

Pounds of methoxychlor/acre	Average number of potato leafhoppers per 20 sweeps		
	1 day post-trt.	7 days post-trt.	14 days post-trt.
1.50	0.24 a*	3.0 a	3.9 a
0.25	1.04 ab	6.1 b	5.9 a
0.13	1.94 bc	7.9 bc	10.3 bc
0.06	3.04 cd	9.9 c	10.8 bc
Untreated	3.68 d	9.6 c	15.3 c

*Numbers followed by the same letter do not differ significantly at the five percent level (Duncan's Multiple Range Test).

Table 3. Plant Parameters Measured in Plots Treated With Different Rates of Methoxychlor for Potato Leafhopper Control

Pounds of methoxychlor/acre	Yield (tons/A)	Percent crude protein	Stem length	
			At harvest	One week after harvest
1.50	1.41	19.7 a*	60 a	16.9 a
0.25	1.47	18.4 b	56 b	13.7 b
0.13	1.38	18.3 b	48 c	12.7 c
0.06	1.35	17.7 bc	43 d	13.1 bc
Untreated	1.34	17.4 c	35 e	11.6 d

*Numbers followed by the same letter do not differ significantly at the five percent level (Duncan's Multiple Range Test).

Weed Control in No-Till

G.E. McKibben

The question is frequently asked: "How long can one no-till without a tillage operation?" We have been conducting research in an attempt to answer this question.

In our research, corn has been grown continuously on plots from 1966 to 1982. Seven seedbeds have been planted no-till; one, plow-plant; and one, conventional. All seedbeds are replicated three times. The soil is Grantsburg silt loam. In 1977 the experimental plan was altered to test continuous soybean culture and a soybean-corn rotation in addition to the continuous corn culture. Each of the original test plots was divided into four equal parts. The northwest quarters were assigned to continuous soybeans, the northeast quarters to continuous corn, the southwest quarters to a rotation of soybeans and corn (soybeans, 1977), and the southeast quarters to a rotation of soybeans and corn (corn, 1977). The seedbed culture for each of the quarters was continued as for the previous eleven years (no-till, plow-plant, or conventional).

Observations have been made of fertility changes, the magnitude of these changes, the influence of surface-applied (no-till) nitrogen, phosphorus, and potassium, and the influence of tillage practices and herbicide treatments (past and present) on the yield of corn and soybeans.

Two hundred pounds of 0-46-0 and 0-0-60 per acre have been applied annually to all plots for the past seventeen years. Until 1978, 50 pounds of 18-46-0 per acre were applied in the row. Since 1978, this fertilizer has been applied in a band over the row. Nitrogen (ammonium nitrate) is side-dressed at 150 pounds on the surface. Two pounds of active ingredient of Furadan are applied in the row on both the corn and soybeans. Diazinon and Mesurol are used on the corn.

Pioneer brand variety 3369A had been planted for several years, but in 1982 Pioneer brand variety 3320 was planted. Williams soybeans are used. Soil samples were taken prior to the application of any fertilizer for the sixteenth year of corn, the fifth year of continuous soybeans (after eleven years of continuous corn), and the fifth year of a rotation of corn and soybeans (following eleven years of continuous corn).

The continuous-corn (northeast quarters, Table 1), no-till plots received four quarts of Princep on April 10, 1982, and the preemergence treatments listed in Table 1 were applied to the no-till, conventional, and plow-plant plots.

In 1982, the rotation corn (southwest quarters, Table 2) on all no-till plots received one quart paraquat plus a surfactant and three quarts Bladex. The conventional and plow-plant seedbeds received two quarts Bladex and two quarts AAtrex.

The seven continuous no-till corn plots (northeast quarters) had an average pH reading for the top one inch of 6.79 (6.77 for 0 to 6 inches); an average P_2 reading for the top inch of 204 (147 for 0 to 6 inches); an average P_1 reading for the top inch of 123

(62 for 0 to 6 inches); and an average K reading for the top inch of 366 (249 for 0 to 6 inches). These values seem adequate to support excellent yields, and the pH values on the surface would not interfere with the triazines.

Herbicides are available for no-till soybean production in corn stalks that will produce satisfactory weed control and yields; these include paraquat plus a surfactant, Sencor, and Lasso. Several new postemergence herbicides, such as Blazer, Basagran, and Poast, are now available for backup. However, a new experimental combination of Bladex and Surflan applied early in the spring (April 5 to 26 in 1982) is showing excellent promise for no-till soybeans in corn stalks at Dixon Springs. The new experimental combination of Bladex and Surflan applied early to corn stalks for no-till soybeans appears to be competitive with the more conventional herbicide treatments (Table 3).

Herbicides are available to provide excellent weed control in no-till. Other herbicides (as discussed above) offer further potential for weed control when clearances are available.

Table 1. Seventeenth Year Continuous Corn (Northeast Quarters), 1982

Treatment[a]		Yield[b] (bu./A)	Population (plants per acre)
A	2 qt. Roundup[c]	115.19	20,618
B 16 lbs. a.i./gal.	2 qt. Roundup; 2 qt. Aatrex; 3/4 pt. 2,4-D (6 lbs. a.i./ gal. l.v. ester); 2 qt. Lasso	145.63	21,780
C	2 qt. Roundup; 2 qt. AAtrex	137.71	20,328
D	None (except 4/10 treatment)	136.05	23,232
E	1 qt. Roundup; 2 qt. AAtrex	103.22	14,230
F	4 qt. AAtrex	130.59	17,134
G	2 qt. Bladex; 2 qt. AAtrex (conventional)	129.67	24,394
H	2 qt. Bladex, 2 qt. AAtrex (plow-plant)	106.29	20,328
I	2 qt. Roundup; 2 qt. AAtrex	126.72	18,876
28	2 qt. Roundup; 3/4 pt. 2,4-D (6 lbs. a.i./gal.); 2 qt. AAtrex; 2 qt. Lasso	164.96	24,394
29	2 qt. Roundup, 3/4 pt. 2,4-D (6 lbs. a.i./gal.); 1 qt. AAtrex; 1 qt. Princep; 2 qt. Lasso	144.34	20,038

[a]Herbicides were applied in 66 gallons of water per acre.
[b]Two samples per replication, average three replications, except plots 28 and 29--two samples per plot.
[c]An extra eight ounces of surfactant was used per 100 gallons of water.

Table 2. Sixth Year Corn (Corn-Soybean) Rotation after Eleven Years of Continuous Corn (Southwest Quarters), 1982

Treatment[a]		Yield[b] (bu./A)	Population (plants per acre)
A		165.02	26,717
B		132.68	23,813
C	Same treatments as continuous	128.63	22,071
D	corn (Table 1) until the	131.45	22,942
E	corn-soybean rotation was	120.77	22,070
F	established in 1977.	116.97	23,232
G		115.00	24,103
H	Treatments in 1982 are	107.27	15,682
I	listed in the text.	132.74	23,813
28		118.93	20,909
29		125.56	25,265

[a]Herbicides were applied in 66 gallons of water per acre.
[b]Two samples per replication, average three replications, except plots 28 and 29 -- two samples per plot.

Table 3. No-Till Soybeans in Corn Stalks, 1982[a]

Treatment	Yield (bu./A)	Population (plants per acre)	Weed control[b]
2.4 qt. Bladex, 1.5 qt. Surflan (4/26)	48.5	141,571	7.5
2.4 qt. Bladex (4/26); 1 qt. Dual, 1 qt. Lorox	48.8	141,571	8.0
2.4 qt. Bladex, 1.5 qt. Surflan (4/26); 1/2 qt. Lorox	46.7	154,203	5.0
2.4 qt. Bladex (4/26); 1/2 qt. Dual; 1/2 qt. Lorox	35.4	151,589	3.5
2.4 qt. Bladex, 1.5 qt. Sencor (4/26)	48.0	162,915	4.5
2.4 qt. Bladex (4/26)	26.2	98,446	2.5
Check	2.4	9,584	0
1 qt. Paraquat + surfactant, 1 qt. Lorox, 1 qt. Dual	34.6	150,718	4.5
1 qt. Paraquat + surfactant, 1/2 qt. Sencor, 1 qt. Dual	44.8	137,650	5.0
1 qt. Paraquat + surfactant, 1-1/2 qt. Sencor, 1 qt. Surflan	45.7	141,571	3.5

[a]Williams 79 soybeans were planted June 11, 1982. Preemergence herbicides were applied on June 12 or 13, 1982. Harvest commenced on October 6, 1982.
[b]Weed control: 0 = no control; 10 = 100 percent control.

Relay Intercropping of Soybeans in Winter Wheat

C.M. Brown

Doublecropping is now an integral part of agriculture in southern Illinois. The most common practice is to harvest a crop of winter wheat in early July, plant soybeans, and harvest those soybeans in the fall of the same year. Success of this practice varies from year to year, usually depending on the availability of moisture at the time of and following soybean planting.

Improved techniques for timely planting and weed control have permitted a northward movement of doublecropping in Illinois, but the farther north one moves, the less reliable the practice becomes.

Relay intercropping could be a method of reducing the risk and extending the northern limit of doublecropping winter wheat and soybeans. With this system, soybeans are planted before winter wheat harvest. Because of earlier planting, the soybeans are more likely to have adequate moisture for establishment and a better chance of maturing before frost damage.

Some researchers and farmers have attempted to establish soybeans in winter wheat by aerially seeding soybeans prior to wheat harvest. A few successful results have been reported, but most attempts have failed. Failures have usually been attributed to failure of the soybeans to germinate and become established.

Compared with aerial seeding, planting of soybeans into the soil should improve the probability of successful establishment of the soybeans. Widening the winter wheat rows might also enhance establishment of the soybeans by reducing competition for moisture and light. Although widening the wheat rows will reduce wheat yields, the benefit to the soybeans should compensate for the reduction in wheat yields.

For several years we have experimented with different systems of relay intercropping soybeans into winter wheat. We have examined such variables as row width of the wheat, times and methods of seeding soybeans in the wheat, varieties of soybeans, and weed control practices.

Winter Wheat Planting

In our system of relay intercropping, the wheat is planted in row widths of 16 inches. This width is accomplished by plugging every other outlet of a conventional eight-inch grain drill. The wheat has been seeded at a rate of 60 to 70 pounds per acre in these wider rows. Wheat yields in the 16-inch rows have ranged from 80 to 95 percent of yields obtained in conventional eight-inch rows under comparable conditions. Although 16-inch row widths appear very well adapted to our system, other row width patterns of the wheat or soybeans might be equally viable or superior under some conditions.

Soybean Planting

We planted the soybeans in 16-inch row widths between the wheat rows at a seeding rate of five to six beans per foot of row. We used unit planters with planter units narrowed to 16 inches and equipped with a no-till coulter in front of each one. Tractor wheels were spaced so that the wheel tracks were between wheat rows, with the outside units of the five-unit planter seeding the soybeans in the tractor wheel tracks.

Soybean planting time should be gauged by the stage of wheat growth instead of by the calendar date. Generally, best results have been obtained by planting between midboot and early heading stages of the wheat. Earlier plantings often lead to early, excessive soybean growth and wheat harvest problems, particularly in years with excess moisture or severe wheat lodging. Regrowth of the soybeans also is hampered if plants are clipped during wheat harvest after the soybeans have entered the reproductive stage of growth.

The choice of soybean variety is important. We have generally had best results with full-season indeterminate varieties. Short-season and determinate varieties often do not develop sufficient vegetation after the wheat harvest.

Weed Control

Relay intercropping of soybeans in winter wheat may sometimes be possible without herbicides. In most fields, however, some herbicides will be required. Weed control with relay intercropping is more difficult than with conventional doublecropping. Widening the wheat rows allows more light penetration and thus leads to less competition between emerging weeds and the wheat. These weeds often become too large for selective herbicidal control in the soybeans after wheat harvest. Thus, herbicides are needed at the time of weed emergence in the spring, usually in mid- to late April. These treatments must be safe on both wheat and soybeans, must control a broad spectrum of weeds, and yet must last until the soybeans form a complete canopy to shade out late emerging weeds.

We have evaluated a number of herbicides, both singly and in combinations, over several years, and some have provided adequate weed control while not causing significant injury to the winter wheat or soybeans.

These treatments, applied over the top of wheat in the fully tillered stage, included herbicides such as Lasso, Dual, Amiben, Surflan, Prowl, Modown, and Sencor. On winter wheat intercropped with soybeans, the longest and most consistent grass control was provided by Surflan or Dual. For control of broadleaf weeds, Modown has provided fair control with little or no injury to either wheat or soybeans. Amiben, alone, provided broad spectrum control early but did not persist long enough. For most fields with a broad spectrum of weeds, our best treatments have been combinations of either Surflan plus Modown or Dual plus Modown.

If needed, it would be possible to control late emerging broadleaf weeds with such herbicides as Basagran or Blazer, and late season grasses with one of the new post-emergence grass killers such as Poast.

Thus, herbicides are now available or about to become available that will provide adequate weed control for relay intercropping of winter wheat and soybeans, once the herbicides are registered for that use.

Yield Results

Table 1 presents the yield results from several years of our relay intercropping experiments conducted at Urbana, Illinois.

In these experiments the soybeans were interplanted between 16-inch, winter wheat rows when the wheat was near midboot to early heading, which occurred from mid-May to early June. A combination of Surflan at 1.5 pounds of active ingredient per acre plus Modown at 2.0 pounds of active ingredient per acre, applied in mid-April when wheat was fully tillered, provided satisfactory weed control. Plots were irrigated with one to two inches of water following soybean planting in the very dry springs of 1978, 1979, and 1980. No supplemental water was applied in 1981.

The data in Table 1 suggest that excellent soybean yields can be produced in this system, provided adequate moisture is available. For example, the variety Williams averaged 45 bushels per acre over the four years. Wheat yields were not measured, but other experiments have shown that wheat yields are reduced five to fifteen percent when grown in 16-inch rows instead of the conventional seven- or eight-inch rows.

In 1981 and 1982 we also tested this relay intercropping system in larger plots at Urbana that were managed essentially as a commercial grower might manage them. The winter wheat variety Roland was planted in the fall in 16-inch rows with a conventional grain drill. The soybean variety Williams was planted between the 16-inch wheat rows when the wheat was in the early heading stage. We also had winter wheat planted alone in 8-inch rows, and soybeans planted alone in 16-inch rows. There was adequate moisture for germination and establishment of the soybeans in both years, and no supplemental water was applied. Results from these two favorable years are presented in Table 2.

Although we obtained excellent results in these experiments, we cannot be sure that this system will be successful at other locations and where supplemental water is not available if needed. We are continuing to evaluate the system at several locations without irrigation. We hope to determine that relay intercropping of soybeans and winter wheat is a feasible practice, particularly in areas too far north for conventional doublecropping.

Table 1. Yields (Bushels per Acre) of Eight Soybean Varieties Relay Interplanted into Winter Wheat at Urbana, Illinois, 1978 to 1981

Soybean variety	Intercropped soybean yields, bu./A				Four-year average
	1978	1979	1980	1981	
Corsoy	29	37	30	40	34
Amsoy 71	37	49	37	46	42
Williams	54	51	29	45	45
Elf	41	36	32	40	37
Will	39	44	33	40	39
Cumberland	51	50	33	41	44
Bonus	44	55	24	35	40

Table 2. Yield (Bushels per Acre) of Wheat and Soybeans in a Relay Intercropping System at Urbana, Illinois, 1981 to 1982

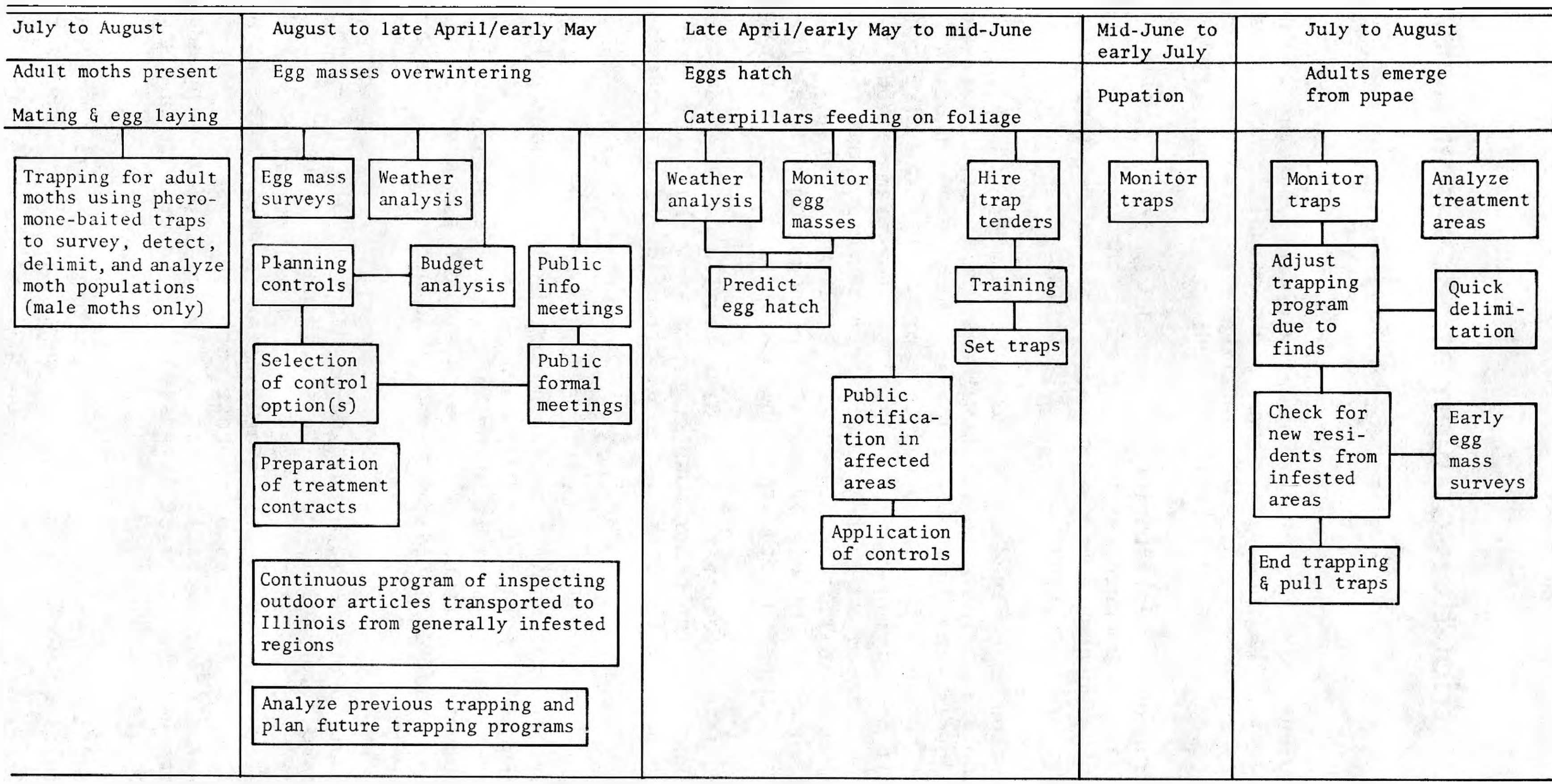
Treatment	Yield, bu./A 1981	Yield, bu./A 1982	Two-year average
Wheat alone (8" rows)	70	66	68
Wheat intercropped (16" rows)	61	58	60
Soybeans alone (16" rows)	48	50	49
Soybeans intercropped (16" rows)	46	40	43

Results of Gypsy Moth Control Programs Conducted in Illinois during 1976, 1980, 1981, and 1982[a]

Year of treatment	Community	County	Acres	Pesticide	Number of applications[b]	Rate per acre	Means of application[c]	Moths caught in the year prior to treatment	Moths caught after treatment[d]
1976	Palos Park	Cook	1,000	carbaryl	2	1 lb.	A	190*	0
1980	McHenry	McHenry	40	Bt.[e]	2[f]	1 lb.	A,G	166*	72
1980	Kildeer	Lake	30	carbaryl	2	1 lb.	A	46*	0
1981	McHenry	McHenry	100	Bt.	2[g]	1 lb.	A,G	72	0
1981	Lincolnshire	Lake	35	carbaryl	2	1 lb.	A	45*	0
1981	Wheaton (Arrowhead)	DuPage	50	carbaryl	2	1 lb.	A	69*	0
1981	Diamond Lake	Lake	3	carbaryl	2	1 lb.	A	17*	0
1982	Downers Grove	DuPage	800	Bt.	2[h]	1 lb.	A	74	28
1982	Wheaton	DuPage	300	Bt.	2	1 lb.	A	286*	103
1982	Wood Dale/ Bensenville	DuPage	500	Bt.	2	1 lb.	A	1,774*	215
1982	Naperville	DuPage	50	Bt.	2	1 lb.	A	49*	29
1982	Crystal Lake	McHenry	100	carbaryl	2	1 lb.	A	49	0
1982	Lake Zurich	Lake	80	carbaryl	1	1 lb.	A	49*	1
1982	Lake Forest	Lake	10	carbaryl	2	1 lb.	A	57*	0
1982	Lindenhurst	Lake	50	carbaryl	2	1 lb.	A	154*	0
1982	Morton	Tazewell	5	carbaryl	2	1 lb.	G	3*	0
TOTAL			3,153					3,066	447

[a]No treatments were carried out during 1977, 1978, and 1979.
[b]Unless otherwise indicated, no supplemental treatments were used in addition to the applications.
[c]A = aerial application and G = ground application.
[d]The lower totals for 1982 can be partially attributed to winter mortality.
[e]Bt. = Bacillus thuringienesis.
[f]Supplemental treatments included ground treatment by citizens, mass trapping (three traps per acre), and larval trapping.
[g]Supplemental treatments included ground treatment by citizens and mass trapping (three traps per acre).
[h]Mass trapping (three traps per acre) supplemented the applications.
*Egg masses were located in addition to adult moths trapped.

Timetable for Monitoring Gypsy Moths



Distribution of Nematodes in Illinois

T.A. Melton III

Nematodes cause plant diseases in every country or region of the world. Because most species occur wherever their host is grown, plant parasitic nematodes can be found in virtually every square foot of soil in Illinois. In fact, an average of one to five plant parasitic nematodes inhabit each cubic centimeter of Illinois cropland.

Many factors influence the distribution of nematodes in individual fields and throughout Illinois. Included are cropping sequence, predominant weed species, soil texture, available nutrients, abundance of competitors or predators, temperature, and oxygen levels. Of these, cropping sequence and soil texture appear to be most influential.

Nematode distribution is defined in two separate but related ways. Distribution can be thought of simply in terms of which nematodes are located where and their approximate population levels, that is, the real distribution. Or their distribution can be charted according to where they pose economic problems. The differences between the two are the result of varying damage thresholds. For example, 300 root-lesion nematodes (*Pratylenchus hexicisus*) per gram of dry root weight may pose an economic threat to a corn grower whose soil is developed from sandy material. These nematodes may not cause damage, however, on darker soils developed from glacial loess. Hence, the nematodes are distributed in both areas, but the problem occurs only in the sandy area.

Nematologists are interested in the real distribution of nematodes. Growers and agribusiness personnel, on the other hand, want to know where the largest potential for nematode damage occurs in the state. The distribution of nematode damage is the focus of this paper.

Ten genera of nematodes have been found affecting row crop production in Illinois. Of these, the soybean cyst and the northern root-knot nematodes parasitize only soybeans. Needle nematodes parasitize only corn. The remaining seven--root-lesion, dagger, stubby-root, stunt, spiral, sting, and lance nematodes--will attack corn or soybeans. Of economic importance on soybeans are the soybean cyst and root-lesion nematodes. Dagger, root-lesion, stubby-root, and needle nematodes are of economic significance on corn.

The known distribution of the soybean cyst nematode equals its economic distribution since soybeans have a low tolerance to this nematode. Assuming that the soybean cyst nematode is not native to Illinois, spread by natural or artificial means primarily accounts for its distribution. Its establishment in northern areas of the state may have been slowed by an abundance of nonhost crops such as corn. If this nematode is native, the primary influence on its distribution is the cropping sequence. A good correlation exists between areas of intensive soybean culture and soybean cyst nematode distribution (Figure 1).

There are two predominant species of lesion nematodes (*Pratylenchus*) in Illinois. Both appear to be more of an economic problem on corn. *P. hexincisus* is found in areas where corn is intensively grown, especially on glacial till and loess soils (Figure 2). In addition to being a problem on corn, *P. scribneri* is an economic problem in soybean, especially in the sandier soils such as alluvial and medium-coarse outwash soils. Although a mixture of *Pratylenchus* species can be found in most soils, one of these two species will usually predominate.

The stunt and spiral nematodes are relatively cosmopolitan in distribution and present few problems to growers. Stunt nematode populations are occasionally high enough to cause minor damage in corn. Their distribution follows no particular pattern throughout the state. Spiral nematode distribution is relatively uniform throughout the state; virtually every field hosts spiral nematodes. Spiral nematodes may contribute to stress situations or disease complexes, but they rarely will cause yield loss, even at high populations.

Some of the most devastating nematode damage in corn is caused by needle, stubby-root, dagger, and lance nematodes. Needle and stubby-root nematodes are found only in soils of coarse outwash or alluvium parentage (Figure 2). Needle nematode distribution is also highly correlated to areas of continuous corn or areas with grassy weed problems. Although dagger and lance nematodes inhabit loess soils, high populations and the resulting damage are found in coarser textured soils.

Northern root-knot and sting nematodes have only been found in isolated cases in extreme southwestern and southeastern Illinois, respectively.

The general distributions outlined here are not definitive. Exceptions are frequently found. Although nematodes cause yield losses in all soil types every year in Illinois, most *obvious* problems are on lighter soils. Most subtle problems (one to five percent yield loss) are on darker soils.

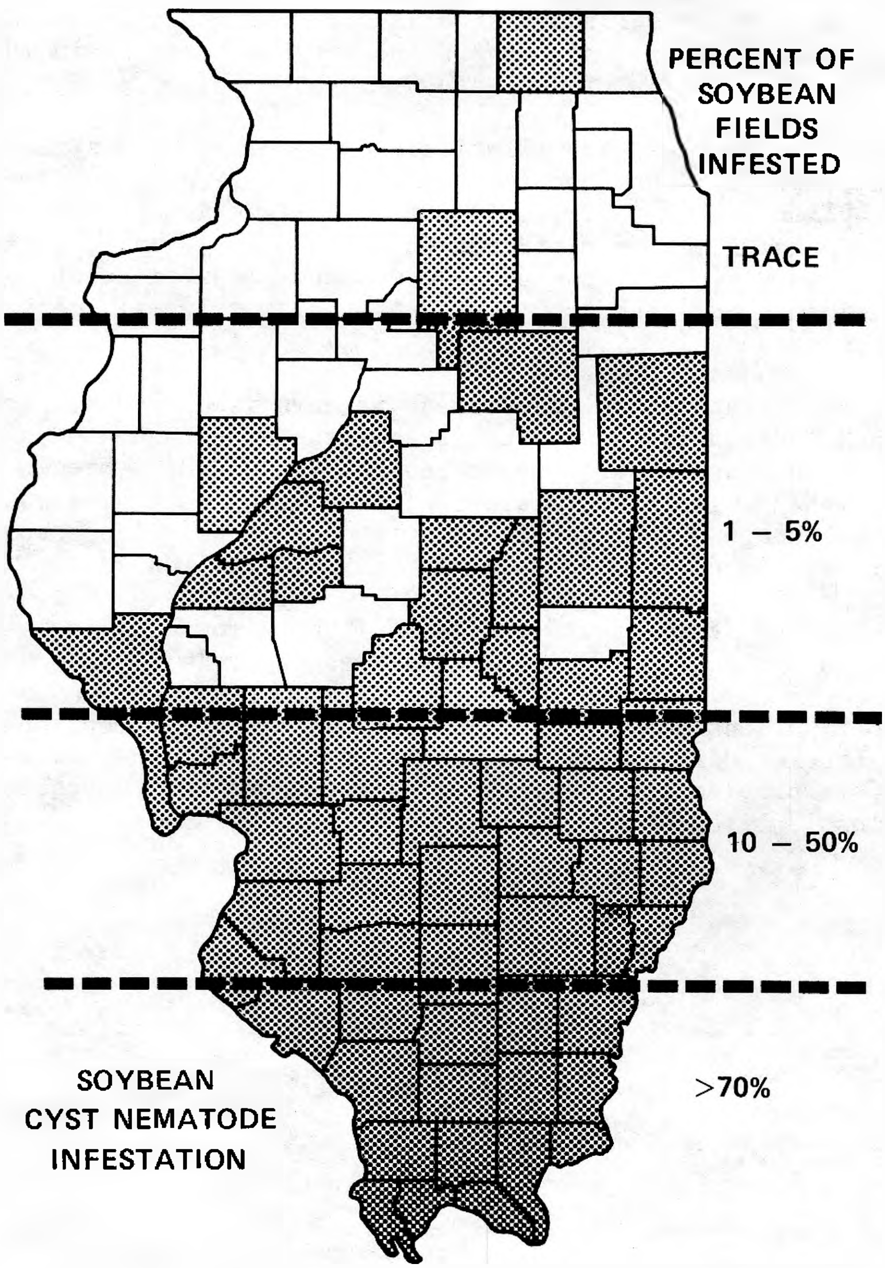


Figure 1. Illinois counties with known infestations of the soybean cyst nematode as of November 1, 1982.

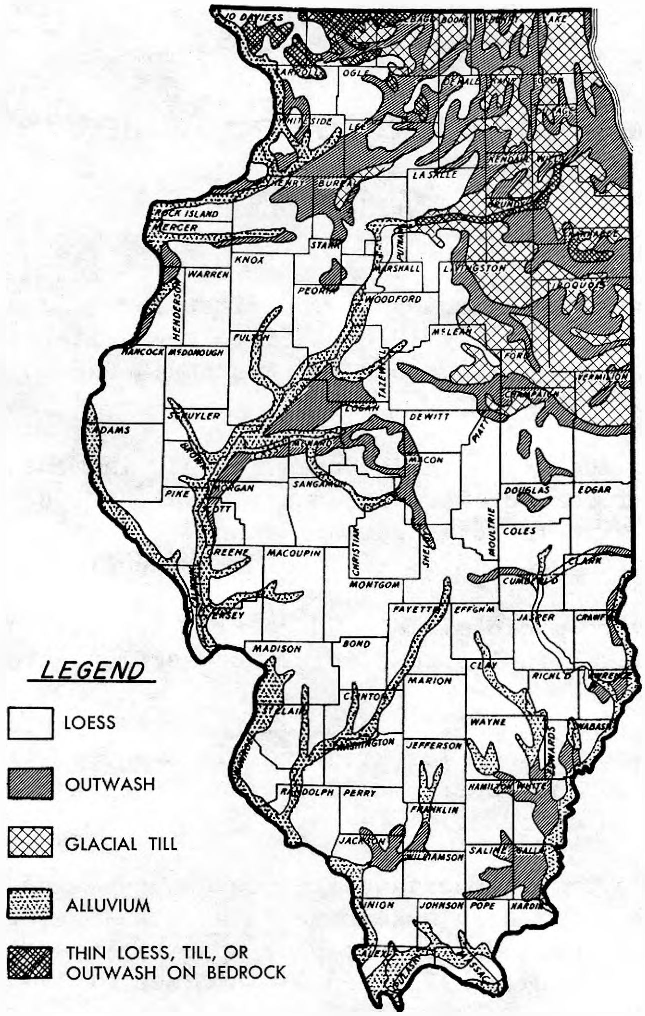


Figure 2. The extent of the main kinds of soil parent materials in Illinois (from Extension Bulletin 725, Soils of Illinois*).*

A Review of Wild Proso Millet in Illinois

H.J. Hopen

Wild proso millet (*Panicum miliaceum* L.) was first recognized as a serious weed threat in the Midwest in the early 1970s. Since then, it has spread rapidly so that it now infests large areas of Minnesota and Wisconsin and border areas of Illinois, Iowa, and North Dakota.

Wild proso millet was identified in Illinois in 1980 in McHenry and Winnebago counties. In 1981 it was reported in Boone County. During 1982 there were no reports of wild proso millet being found in any additional Illinois counties, although it did spread to some additional fields in the three counties already identified.

For a description of wild proso millet and control suggestions, see *Agronomy Facts* W-44, "Wild Proso Millet," in the weed reference section later in this manual.

Eradicane Extra (EPTC + safener + extender) may initially provide some measure of extended control. However, some research and field observations from several Midwest states indicate that control levels may drop when Eradicane or Eradicane Extra is used on the same area in consecutive years.

Early detection is of primary importance in preventing large-scale spread of wild proso millet in Illinois. Please make note of any "tall-growing" panicum species in the northern part of Illinois and report your observations to your county Extension adviser. Your cooperation will help keep us informed of the possible spread of this weed species.

Experimental Soil Insecticides for Corn Rootworms

E. Levine

Corn rootworms continue to be a major problem for growers of continuous corn in Illinois. Each year we evaluate experimental soil insecticides for their control of corn rootworm larvae. These insecticides may be of new chemistry, or they may simply be a different formulation of a registered material. These compounds are compared with materials currently marketed in Illinois. Promising candidates may be marketed in the future if economic and other considerations (for example, mammalian toxicity, mammalian mutagenicity, behavior in the environment, and effects on beneficial insects and wildlife) are favorable.

Soil insecticides were evaluated at two locations in Illinois in 1982. Corn was planted in 30-inch rows on May 1 in the central part of the state at Bloomington and on May 14 in the east central area at the Agronomy South Farm of the University of Illinois in Champaign. The varieties planted were Funks G-4522 at Bloomington and Pioneer 3780 at the South Farm. Each insecticide was applied in a 7-inch band over the row within five days of planting with Noble metering units attached to a bicycle-wheeled applicator equipped with drag chains. Each treatment was applied to a single, 50-foot-long row. The experiments were arranged in randomized, complete-block designs with four replications per treatment.

In 1980 and 1981, Counter had been applied at a rate of one pound of active ingredient per acre on the South Farm field. No soil insecticides had been used at the Bloomington location in either 1980 or 1981. Both fields had high corn rootworm beetle counts during the preceding summer.

We evaluated the root systems for rootworm damage in early July by digging up and washing 20 plants from each treatment (five roots times four replications) and then examining the roots for rootworm feeding damage. A damage rating scale of one to six was used for measuring and evaluating insecticide effectiveness (Table 1).

Only light to moderate rootworm larval pressure was encountered in the two study sites. Consequently, most of the compounds tested performed adequately (root ratings of 3.0 or less), as is shown in Tables 2 and 3. Additional tests under greater rootworm pressure will be needed for us to assess the true effectiveness of these compounds.

Two controlled-release formulations of carbofuran (Furadan)--Sierra 32-45-2 and Sierra 41-4-2--were also evaluated at the South Farm location. These materials did not protect the root systems against rootworm larvae any better than Furadan 15G.

We did not find any major differences in control this year between the two chemical classes of rootworm insecticides, the carbamates and organophosphates. No phytotoxicity was observed with any of the treatments.

Table 1. Root Rating System

Rating	Damage
1	No visible damage or only a few minor feeding scars.
2	Some roots with feeding scars, but no roots pruned within 1.5 inches of plant.
2.5	One or two roots pruned within 1.5 inches of plant.
3	Several roots pruned within 1.5 inches of plant.
4	One node (or the equivalent) of roots pruned within 1.5 inches of plant.
5	Two nodes (or the equivalent) of roots pruned within 1.5 inches of plant.
6	Three or more nodes of roots pruned within 1.5 inches of plant.

Table 2. Corn Rootworm Insecticide Evaluation, Agronomy South Farm (Champaign County), 1982

Treatment*	Rate (pounds of active ingredient per acre)†	Mean root rating**
Landrin 14G RB‡	1.00	2.0 a
Furadan 15G‡	1.00	2.0 a
Mocap 10G	1.00	2.0 a
Mocap 15G	1.00	2.1 a
Landrin 15G‡	1.00	2.1 a
Counter 15G	1.00	2.1 a
Mocap 20G	1.00	2.1 a
Amaze 20G	1.00	2.1 a
Advantage 15G‡	1.00	2.1 a
Sierra 32-45-2 8.9G‡	1.00	2.2 ab
Landrin 5G‡	1.00	2.2 ab
Lorsban 15G	1.00	2.2 ab
Landrin 15G‡	0.80	2.2 ab
Oncol 5G‡	1.00	2.2 ab
Dyfonate 20G	1.00	2.3 ab
Sierra 32-45-2 8.9G‡	2.00	2.3 ab
BAS 263-12 20G‡	0.75	2.3 ab

Table 2. (Continued)

Treatment*	Rate (pounds of active ingredient per acre)†	Mean root rating**
Landrin 20G‡	1.00	2.4 ab
BAS 263-12 20G‡	1.00	2.4 ab
Thimet 20G	1.00	2.4 ab
Sierra 41-4-2 9.3G‡	2.00	2.4 ab
Ethion 10G	1.50	2.6 b
Sierra 41-4-2 9.3G‡	1.00	3.1 c
Check	--	3.2 c

*Treatments in italics are currently marketed formulations.
†Based on 40-inch row spacing.
**The root-damage rating scale includes six categories ranging from no damage (1) to severe damage (6). The means are based on 20 observations (five roots per treatment times four replications). Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).
‡Carbamates.

Table 3. Corn Rootworm Insecticide Evaluation, Bloomington (McLean County), 1982

Treatment*	Rate (pounds of active ingredient per acre)†	Mean root rating**
BAS 263-12 20G‡	1.00	1.9 a
BAS 263-12 20G‡	0.75	2.1 ab
Amaze 20G	1.00	2.1 ab
Counter 15G	1.00	2.1 abc
Thimet 20G	1.00	2.2 abcd
Landrin 15G‡	1.00	2.3 abcd
Dyfonate 20G	1.00	2.4 abcd
Furadan 15G‡	1.00	2.4 bcd
Lorsban 15G	1.00	2.4 bcde
Advantage 15G‡	1.00	2.5 bcdef
Oncol 5G‡	1.00	2.6 cdef
Mocap 15G	1.00	2.7 def
Mocap 10G	1.00	2.9 ef
Mocap 20G	1.00	3.0 f
Check	--	4.0 g

Footnotes are the same as for Table 2.

Integrated Control of Alfalfa Diseases

H.W. Kirby

Diseases may reduce alfalfa yields up to 30 percent or more each year in Illinois, depending on the diseases involved, the varieties grown, the management practices followed, and various environmental factors. Approximately 30 different diseases commonly reduce yields, forage quality, and longevity of alfalfa stands in Illinois.

Losses can be minimized by a comprehensive disease management program that integrates elements such as (1) growing winter-hardy, disease-resistant varieties; (2) planting top-quality, disease-free seed grown in an arid area; (3) providing a well-drained, well-prepared seedbed; (4) using a crop rotation of several years or longer with non-legume crops; (5) cutting to maximize high-quality forage and minimize losses to leaf and stem diseases; (6) creating a balanced soil fertility and proper soil reaction (pH) based on a soil test; (7) avoiding cutting or overgrazing during the last five or six weeks of the growing season to allow food reserves to build up before frost; (8) controlling insects and weeds; (9) cutting only when the foliage is dry; (10) plowing down unproductive stands; and (11) following other suggested cultural practices.

An integrated disease control program is based on knowledge about which yield-reducing diseases are most likely to occur in an area and the diseases' cycles.

Control measures are currently not recommended for several common alfalfa diseases, including bacterial blight or leaf spot, bacterial stem blight, downy mildew, and rust. Resistant varieties are available for many of these diseases.

Disease-Resistant Varieties

Growing varieties that are winter hardy, high yielding, and disease resistant is the most economical, efficient, and easiest way to control alfalfa diseases. Resistance to bacterial wilt, common leaf spot, Lepto leaf spot, spring black stem, anthracnose, and Phytophthora root rot is of major importance in Illinois. No alfalfa variety is resistant to more than a few of the major diseases. Several of the newer varieties, however, are resistant to the important leaf and stem diseases. Alfalfa producers should select varieties according to local adaptability, high yield potential, and resistance to the most common and serious diseases in their area. For the best information on how a given variety is likely to perform in a particular area, check with your county Extension adviser and see the current issue of the Agronomy Handbook. Because planting disease-resistant alfalfa varieties will *not* control all diseases, the integrated use of other control measures is necessary.

Planting Site and Crop Rotation

The planting site often determines which diseases are likely to occur since most disease-causing organisms (pathogens) survive between growing seasons on or in crop debris, volunteer alfalfa, and alternate host plants. These pathogens die out once this crop residue has thoroughly decayed.

In areas or fields where clean plowing to promote the decay of crop residue is not possible, it is *most* important to use all other available disease management practices. Depending on a single practice is not proper disease management and may result in substantial crop losses.

Some disease-causing organisms are found in every field, regardless of the cultural practices. For example, rust spores may be carried by the wind for many miles before descending on alfalfa plants (often in a rainstorm). Alfalfa mosaic viruses are transmitted by aphids that may be blown considerable distances.

The diseases strongly associated with continuous alfalfa production include bacterial wilt, a variety of dry fungal root and crown rots, anthracnose, Phytophthora root rot, Fusarium wilt, spring and summer black stem, common and Lepto leaf spots, bacterial leaf spot, and Stagonospora leaf and stem spot. Rotating crops and using tillage programs that permit residue decomposition before the next alfalfa crop is planted will help reduce the incidence of many of these diseases.

Of the fungi and bacteria that attack alfalfa plants, very few infect plants in the grass family, which includes corn, small grains, sorghum, and forage grasses. Rotations of three or four years with a grass crop deprive alfalfa pathogens of a host plant on which to feed, reproduce, and carry over between alfalfa crops.

Balanced Fertility

Adequate and balanced levels of lime, phosphorus (phosphate), potassium (potash), and other nutrients can be important in reducing disease losses. An adequate level of nitrogen (through *Rhizobium* nitrogen fixation) must be available for top yields and must be balanced with the phosphate and potash levels. New plantings should receive an application of 25 to 50 pounds of nitrogen per acre unless the organic-matter content of the soil is greater than 25 percent, or the preceding crop was a well-nodulated legume crop. Losses from a number of root and crown rots can increase where the phosphate and potash in the soil are inadequate. Leaf and stem diseases are often more severe where there is excess nitrogen or too little potash. Soil pH levels of 6.5 to 7 are necessary for the maximum availability of needed nutrients and for good nodulation. Healthy and vigorous plants can tolerate diseases better than other plants and are able to produce a near-normal yield despite disease.

High-Quality Seed

Many important alfalfa pathogens can infect seeds. Pathogens may also be carried with or on seeds. Examples of seed-transmitted diseases include certain mosaics, downy mildew, seed rot, damping-off, seedling blights, several different crown and root rots, spring black stem, yellow leaf blotch, Stemphylium leaf spot, and bacterial blight or leaf spot. Dodder and stem nematode infections may also be transmitted by seeds. Mature, certified seed produced in arid regions is usually free of pathogens. Avoid planting seeds produced in the southern states or in foreign countries.

Seeds infected by pathogens are often of low quality. Poor-quality seed may result in low germination, low vigor, and poor, uneven stands--especially if the seedbed is cold and not well prepared and the soil pH is below 6.5. To minimize losses, plant only certified, high-quality seed with a germination rate greater than 80 percent. Fungicide seed treatments are *not* normally justified in Illinois, although such treatments may produce improved stands when adverse seedbed conditions exist. Stands grown from low-quality seed, even if properly treated, do not equal stands from untreated, high-quality seed. Seed lots should be tested before planting to ensure good stands of vigorous seedlings.

Plump, high-quality seed that is free from disease-causing organisms will produce vigorous stands with fewer losses from seed rot, damping-off, and seedling blight fungi. In general, seed-rotting and seedling-blight fungi cause severe problems only where diseased or low-vigor seed is used. Planting high-quality seed in a moist, well-drained, well-prepared seedbed at the proper depth and spacing will ensure good stands of vigorous seedlings, which are important factors if high yields are to be realized and weed problems are to be minimized.

Alfalfa Harvest

Cutting heavily diseased stands before bloom and before the leaves fall will maintain the quality of the hay and remove the leaves and stems that are the source of infection (primary inoculum) for later disease. Succeeding cuttings thus will have a better chance of remaining healthy. For the best yield, succeeding harvests should be spaced 30 to 40 days apart. Cut early enough to avoid rank foliar growth that is unusually tall. Cut the alfalfa short, leaving a stubble of 1-1/2 to 2 inches. Cutting in the mid- to late-bud stage, harvesting at 30- to 40-day intervals, and cutting the alfalfa short help to control most leaf and stem diseases of alfalfa.

Cut only when the foliage is dry. This practice avoids spreading the fungi and bacteria that cause leaf and stem diseases, wilts, and crown and root rots.

Do not cut or graze during the last five or six weeks before a killing frost is anticipated (about September 1 in northern Illinois to September 25 in southern Illinois). A top growth of six to eight inches is needed for building food reserves before winter. Fields on well-drained soils may be cut or pastured after the growing season has ended. This helps prevent stand loss from a variety of root and crown rots.

Insect Control

Insects commonly provide wounds by which wilt, crown- and root-rotting fungi, and bacteria enter plants. Insects also reduce plant vigor, increasing the risk of stand loss from wilts and root and crown rots.

In general, controlling the aphids that spread mosaic viruses is impractical. Alfalfa producers should follow the current suggestions given by Extension entomologists from the University of Illinois and their county Extension advisers.

Weed Control

Do *not* allow a thick growth of weeds to mat around alfalfa plants. Like rank, tall growth, weeds reduce air movement, slow the drying of the foliage, and lead to serious crop losses from leaf and stem diseases. Seedling stands under a thick companion crop, such as oats, are commonly attacked by leaf and stem diseases. Weeds also may harbor viruses that can be transmitted to alfalfa by the feeding of aphids. Keep down broadleaf weeds in fence rows, drainage ditches, along roadsides, and in other waste areas. Such places serve as a source of mosaic viruses. Whenever possible, do *not* grow alfalfa close to other legumes--especially clovers, garden peas, and beans. Many of the same viruses that infect alfalfa also attack these and other legumes.

An Integrated Control Plan

The goal of control measures is to disrupt the combination of factors necessary for disease development: a favorable environment, susceptible plants, sufficient quantities of a virulent pathogen capable of rapidly reproducing and spreading, and adequate time for the disease to develop. Disease-control programs are based on an understanding of pathogens, disease cycles, which plant parts are attacked and when, and the factors involved in spreading the pathogens. Control may sometimes be achieved by a single practice, but the long-term reduction of disease losses generally requires the application of several control measures.

Adopting a comprehensive management program for diseases will sharply reduce losses in yields and hay quality. Disease-related losses often make the difference between realizing a profit or sustaining a loss. Alfalfa producers who identify potential disease problems promptly and take action to prevent losses are more likely to produce high yields of top-quality forage than those who do not. Table 1 lists the relative effectiveness of various methods for controlling major alfalfa diseases.

Table 1. Alfalfa Diseases That Reduce Yields in Illinois and the Relative Effectiveness of Various Control Measures[a]

Disease	Planting winter-hardy, resistant varieties	Using high-quality seed	Having a well-drained soil; pH, 6.5 to 7	Employing correct crop rotation	Achieving adequate, balanced fertility	Cutting in the mid- to late-bud stage	Avoiding late cutting and planting	Avoiding rank growth and high stubble	Maintaining insect and weed control
Bacterial wilt	1		2	3	3	3			3
Dry root and crown rots, decline	3	3	2	2	2		2	3	2
Phytophthora root rot	1		2	2	3		2		
Fusarium wilt	1		3	2	3		2	3	3
Verticillium wilt	1								
Anthracnose	1		3	1	2			2	3
Spring black stem	1	2	3	1	3	2		2	3
Summer black stem		2	3	2	3	2		2	3
Common or Pseudopeziza leaf spot	1		3	2	2	2		2	3
Stemphylium or zonate leaf spot	3	2		2	3	2		2	3
Lepto or pepper leaf spot	2		3	2	3	2		2	3
Yellow leaf blotch		2	3	2	2	2		2	3
Stagonospora leaf and stem spot			3	2	3	2		2	3
Rhizoctonia stem blight		2	2		2	2		2	3
Seed rot, seedling blights, damping-off		1	2	3	2				3
Sclerotinia crown and root rot		3	2	3	3	3	2	2	2
Mosaics		3							2

[a] 1 represents a highly effective control measure; 2, a moderately effective measure; and 3, a slightly effective measure.

Cutworm Control in No-Till Corn

D.E. Kuhlman

Very little information is available on the potential for cutworm problems or the efficacy of soil insecticides in no-till corn. During the past few years, county Extension advisers and others have reported an increase in the relative incidence of cutworm problems in no-till corn as compared with the incidence in conventional or reduced tillage systems.

Data have been quite variable from previous tests on controlling cutworms with various soil insecticides under conventional or reduced tillage. Consequently, tests were conducted in no-till corn following corn to determine the efficacy of several insecticides in controlling black cutworms. The tests were conducted in 1982 at two sites on the Southern Illinois University Research Field at Belleville.

Materials and Methods

The experimental design used in these tests was a randomized complete block with four replications. Each treatment was four rows in width and 100 feet long. The insecticide treatments were Lorsban 15G at one pound active ingredient per acre (a.i./A), Dyfonate 20G at one pound a.i./A, Mocap 10G at one pound a.i./A, and Orthene 80 Seed Protectant at eight ounces per 100 pounds of seed. An untreated check was included in each replication.

The granular-soil insecticides were applied in a seven-inch band ahead of the press wheel with a Noble metering unit mounted on a White planter.

The plots were planted on May 11 and evaluated for cutworm damage on May 28 and June 3. On May 28 the plants were in the two-leaf stage; on June 3, most plants were in the four-leaf stage (leaf collars evident on four levels). The cutworms collected on May 28 were mostly sixth and seventh instar. On June 3, cutworm damage was still evident but had declined substantially from observations taken on May 28.

The evaluation consisted of counting the number of undamaged plants and plants cut off by cutworms in the two center rows of each treatment for a distance of 100 feet, thus making a total of 200 feet of row per treatment. The plants that were cut on May 28 were marked with a flag to enable newly cut plants to be identified at the final evaluation on June 3.

Results

The black cutworm infestation was economic in both the north and south no-till corn plots at the Southern Illinois University Research Field. At the time the corn was planted on May 11, the plots were heavily infested with shepherd's purse and chickweed. These weeds were probably very attractive to cutworm moths for oviposition through March and April.

Cutworm feeding reduced plant populations by 33 percent in the north plot and 21 percent in the south plot when the treatment that had the highest number of healthy plants (Lorsban 15G) is compared with the untreated check. Because we were unable to measure the amount of cutting that had occurred before the plants emerged, we assumed that the final stand of healthy plants taken on June 3 would indicate the overall protection provided by each treatment.

In these tests, the planting-time treatments of Lorsban 15G and Dyfonate 20G gave the best protection against cutworms in both the north and south plots, based on the mean number of healthy plants per acre (Table 1).

In the north plot, there were approximately 21,000 undamaged plants per acre where Lorsban 15G was applied and 19,600 where Dyfonate 20G was applied. The areas where Mocap 10G and the Orthene 80 Seed treatment were applied each had about 17,000 healthy plants per acre compared with 14,000 for the untreated check.

In the south plot, the areas treated with Lorsban 15G and Dyfonate 20G had 21,600 and 21,000 healthy plants per acre, respectively. The plots with the Mocap 10G and the Orthene 80 seed treatments, with 18,000 and 17,200 healthy plants per acre, respectively, were similar to the untreated check.

Table 1. Black Cutworm Control in No-Till Corn, Southern Illinois University Research Field, Belleville, Illinois, 1982

Treatment	Pounds active ingredient per acre	Placement*	Mean number of healthy plants per acre†	Percentage of best stand**	Mean number of cut plants per acre†,‡	Percentage of cut plants‡	Bu/A No. 2 corn†
			North Plot				
Lorsban 15G	1	7"-band	20,952 a	100.0	305 a	1.5	130 a
Dyfonate 20G	1	7"-band	19,602 a	93.6	697 ab	3.6	129 a
Orthene 80 Seed Treatment	8 ounces per 100 lbs. seed	On seed	17,141 b	81.8	915 bc	5.3	113 b
Mocap 10G	1	7"-band	16,966 b	81.0	1,198 bc	7.1	112 b
None	-	-	14,048 c	67.0	1,263 c	9.0	107 b
			South Plot				
Lorsban 15G	1	7"-band	21,606 a	100.0	218 a	1.0	158 a
Dyfonate 10G	1	7"-band	20,974 a	97.1	566 ab	2.7	156 ab
Mocap 10G	1	7"-band	18,056 b	83.6	1,176 b	6.5	139 bc
Orthene 80 Seed Treatment	8 ounces per 100 lbs. seed	On seed	17,228 b	79.7	1,089 b	6.3	134 c
None	-	-	17,054 b	78.9	1,111 b	6.5	136 c

*Treatments applied on May 11, 1982.

†Calculations based on average number of plants per 200 feet of row on June 3, 1982. Means based on four replications. Means followed by the same letter are not significantly different at five percent level (Duncan's Multiple Range Test).

**The best stand in these trials occurred in the plots treated with Lorsban 15G.

‡Does not include plants cut before they emerged.

Controlling Problem Weeds

M.D. McGlamery

Annual Weeds

Annual weeds continue to cause problems in Illinois soybeans and corn as evidenced by the topics at this conference on volunteer corn, wild proso millet, and black nightshade. Giant foxtail is still the most widespread annual weed in Illinois, but it is not the most difficult to control. Velvetleaf is difficult to control in corn and soybeans, but it does not cause the yield or harvest problems that cocklebur, jimsonweed, and morningglory cause, especially in soybeans. Common ragweed and giant ragweed were special problems in 1982 along with black nightshade. For more information on annual weeds, see the paper on controlling broadleaf weeds in soybeans by Dr. Tom Jordan of Purdue. The *1983 Row Crop Weed Control Guide* in the weed reference section later in this manual also covers most of these weeds.

Wild cucumber and bur cucumber are special problem annuals. Their seeds germinate over several weeks. Soil-applied herbicides usually fail to prevent late season problems. Atrazine rates can be increased to give sufficient control, but soybeans cannot be grown the next year. Blazer has given initial control of these weeds in soybeans, but directed emergence applications of Lorox or Sencor are needed to control later emerging weeds. These treatments also require special application equipment not generally available in the Corn Belt.

Woolly cupgrass, fall panicum, and foxtails often appear as problem grasses where atrazine is used as the only herbicide or where rainfall does not occur soon enough for preemergence herbicides. These weeds can be controlled by proper selection of "grass" herbicides. Woolly cupgrass control is better with Sutan+, Eradicane, Treflan, Basalin, or Prowl than with Dual or Lasso. Woolly cupgrass was discussed in the *1981 Illinois Custom Spray School Manual* by Dr. Miller of Minnesota (page 171).

Perennial Weeds

Problem Grass Perennials

Shattercane, sorghum almum, and johnsongrass are problem grasses of the sorghum family. Shattercane is an annual; sorghum almum is a weak perennial; and johnsongrass is a strong perennial spreading both by seeds and rhizomes. Seedling control is necessary to control all three of these weeds. There are several options for controlling these weeds in soybeans, and the new postemergence "grass" herbicides Poast and Fusilade provide us another postemergence alternative besides Roundup through a rope-wick or recirculating sprayer. Sutan+ or Eradicane in corn and Treflan, Basalin, Prowl, and Vernam in soybeans can effectively control these "weedy sorghum" seedlings. To control rhizome sprouting, however, it will be essential to use these herbicides at the 1.5 to 2X rate and to follow a thorough tillage program to cut the rhizomes into small sections.

One of the problems with controlling sorghums in corn is that corn is planted in late April or early May when the soil temperature reaches 50° F., and sorghums germinate when the soil temperature is over 60° F. Thus it is necessary to use the high rate of Sutan+ or Eradicane to have persistent control. Eradicane Extra has been formulated for use where Eradicane has failed to provide persistent control because of previous use. Wisconsin had problems in 1982, however, with Eradicane Extra for this use.

Quackgrass and wirestem muhly are two other perennial grasses that are problems in northern Illinois. Wirestem muhly is a warm season perennial, while quackgrass is a cool season perennial. The best program for wirestem muhly control in corn in the past has been delaying planting and tillage until after the rhizomes have germinated and then using a high rate of atrazine. Poast and Fusilade may provide control of wirestem muhly in soybeans. Yellow nutsedge is another perennial monocot (not a grass) that is a problem in Illinois. The *1983 Row Crop Weed Control Guide* discusses control of johnsongrass, quackgrass, and yellow nutsedge.

Problem Broadleaf Perennials

Jerusalem artichoke, field bindweed, hedge bindweed, climbing or honeyvine milkweed, common milkweed, hemp dogbane, bigroot morningglory (wild sweet potato), and trumpet creeper are other perennial broadleaf weeds that are problems in Illinois corn and soybeans.

Jerusalem artichoke is a perennial sunflower that reproduces by seeds and tuberous roots. Banvel, 2,4-D, and Roundup are translocated herbicides that will control Jerusalem artichoke, although high rates of atrazine also will control this weed. Banvel is more effective than 2,4-D, and Roundup is nonselective unless applied through an over-the-top directed applicator in soybeans or as a spot treatment in corn or soybeans. Basagran, Blazer, and Dyanap may defoliate Jerusalem artichoke, but they will not control the roots.

Field and hedge bindweed are often called morningglory, but they are deep-rooted perennials. Banvel and 2,4-D can provide some control in corn. The ester formulations of 2,4-D tend to be more effective than the amine formulations. Roundup can be used as a spot treatment in corn or soybeans at the rate of four to five quarts per acre, and Tordon provides effective control on noncrop land. These materials provide best control when applied either at the bud to bloom stage or at the fall regrowth stage before frost. Blazer, Basagran, and Dyanap will give some suppression of the bindweeds when applied postemergence in soybeans.

Bigroot morningglory (wild sweet potato) is a severe problem in several fields in Illinois. It is a perennial morningglory with a large tuberous root. A postemergence application of 2,4-D at bloom stage can provide some control in corn. Because the bloom stage of this weed usually occurs during the tassel to dough stage in corn, application during silking can cause seed-set problems in corn and require either high-clearance equipment or a plane, both of which create a drift problem to soybeans.

Honeyvine (climbing) milkweed is another perennial vine that causes problems. Its growth can be suppressed in corn with the application of 2,4-D amine at one pint per acre before vines are one to two feet long but after leaves have fully expanded. If vines are greater than two feet long, then use one-half pint per acre of 2,4-D ester rather than amine. Blazer will sometimes defoliate honeyvine milkweed, but it will not prevent resprout.

Hemp dogbane and common milkweed are often confused and called "milkweed." Hemp dogbane branches at the top, while common milkweed does not branch and has bigger and thicker leaves and seed pods than hemp dogbane. Both of these weeds can be controlled by spot treatment with Roundup. Hemp dogbane requires four quarts per acre, and milkweed requires three quarts per acre of Roundup. Application of Roundup through a recirculating spray or rope-wick applicator can provide some suppression of these weeds. However, the time for maximum translocation of Roundup to the roots does not occur at the same time for best coverage, which is when there are maximum height differences between the soybeans and the weeds. The rate of 2,4-D or Banvel registered for early postemergence use in corn is not sufficient to control these weeds. 2,4-D is cleared at higher rates after corn is past the soft dough stage and can provide some effective suppression. Banvel also has a between-crops label rate that will control hemp dogbane if there are adequate leaves and if the plants are actively growing after harvest. The use of Banvel is only possible after wheat harvest, of course, if the wheat is not undersown with a legume or double cropped.

Swamp smartweed is a perennial smartweed usually found around wet spots in fields. Banvel applied at one pint before corn is five inches tall or at one-half pint after corn is five inches tall can give some suppression of this weed.

Canada thistle control is discussed in the *1983 Row Crop Weed Control Guide*.

An Increase in Perennial Weed Problems

Why are perennial weeds increasing problems in corn and soybeans? Better control of annual weeds combined with less tillage, cultivation, crop rotation, and usage of 2,4-D has allowed perennial weeds to increase. Chisel plows and field cultivators tend to spread roots and rhizomes more than moldboard plows and disks. Less cultivation plus failure to control perennial weeds with most soil-applied herbicides has allowed perennial weeds to flourish.

Ways to Control Perennial Weeds

What are some ways to control perennial weeds? You can starve the root system with constant cultivation or mowing. Two to three years of alfalfa with its multiple cutting schedule will often provide effective control of many upright perennial weeds such as common milkweed, hemp dogbane, and Jerusalem artichoke. If the root system is shallow, then thorough cultivation combined with a meristematic inhibitor at high rates may provide some control. This combination is the principle used for controlling johnsongrass with dinitroaniline and thiocarbamate herbicides. Placing the meristematic-inhibitor herbicides of Lasso and Dual next to the yellow nutsedge crowns is another example of this principle.

If translocated herbicides are to be used, then it is best to delay tillage and to leave the root system intact until after the herbicide has translocated to the root. Effective translocation to the root requires that you apply the herbicide at a time when the food reserves in the root are being replaced. Most foliar translocated herbicides move with the photosynthate (carbohydrates produced in photosynthesis) to the demanding meristematic areas. The two critical periods when photosynthate is moving to the roots in many perennials are the early bud to bloom stage and the fall regrowth stage after seed production, when food reserves are being moved to the roots prior to winter. For effective herbicide coverage, leaves must be fully expanded and intact and plants must be actively growing.

It may be necessary to plant an early maturing corn hybrid or soybean variety or to plant small grains to provide for effective fall treatment of warm season perennials. Nonselective rates of translocated herbicides can be used after harvest where wheat or oats are not underseeded to a legume (clover or alfalfa) or double cropped to soybeans or sorghum. Early harvested corn silage may also allow sufficient regrowth for effective control.

Translocated Herbicides for Perennial Weed Control

Which translocated herbicides with biochemical or placement selectivity give effective control of perennials? Banvel and 2,4-D are translocated herbicides that can suppress some perennials in corn. Banvel (4S) is cleared at one pint until corn is five inches tall and at one-half pint per acre until corn is 36 inches tall (24 inches tall where soybeans are being grown). Four-pounds-per-gallon formulations of 2,4-D can be used postemergence on corn at the rate of one pint of amine or one-half pint of ester until corn begins to tassel. However, drop nozzles are required after corn is eight inches tall to minimize corn injury.

Roundup (glyphosate) can be used through selective applicators (rope wicks or recirculating sprayers) to suppress perennial weeds that grow over six inches above the soybean height. Unfortunately, the time of this height difference may not be the best time for translocation to the roots. Roundup is also cleared as a spot treatment at two to five quarts per acre in corn, soybeans, and small grains to control many perennial weeds; this is a nonselective treatment, however, and must be applied before silking of corn, podding of soybeans, or heading of small grains. All crop plants contacted by spray will be killed. Do not till for five weeks before and one week after application.

Poast and Fusilade are selective postemergence herbicides that translocate to the rhizomes of perennial grasses. Johnsongrass and wirestem muhly are more easily controlled than quackgrass.

Tordon and amitrole are noncrop land herbicides that translocate and control many perennial broadleaf weeds. Amitrole will also control perennial grasses. Dalapon will translocate and control perennial grasses. Amitrole and dalapon only persist for two to four weeks in the soil, but Tordon (picloram) can persist for two to three years.

Basagran can be used postemergence in corn or soybeans to control yellow nutsedge or Canada thistle. It may also provide partial control of field and hedge bindweed. Blazer and Dyanap can defoliate many perennial weeds and thus provide partial control. Blazer lists only partial control of common milkweed and the bindweeds on its label, while Dyanap's label lists the bindweeds plus Canada thistle as partially controlled or suppressed.

Retreatment is often required for effective control of most perennial weeds. Retreatment means more than once per year where legal and possible or over several years. Human persistence is often a greater requirement than herbicide persistence. The first treatment may just weaken the plant; retreatment may provide the "knockout." Most perennial weeds propagate by both seeds and vegetative parts. Reinfestation can occur from seeds as well as by rhizomes, tubers, and budding roots. It will be necessary to "keep at it" for a control program to be effective.

Insect Situation and Use of Insecticides in 1982

C.E. Colwell

Highlights

As in past years, weather played a fundamental role in determining insect population levels across the state. Cool temperatures and extraordinarily heavy spring rains can be credited for significantly reducing pest populations. In terms of insect numbers and resulting injury, 1982 will go on record as one of the most subdued years in Illinois agricultural history.

Information obtained from county Extension advisers rates the black cutworm as the most troublesome insect of the year, as it was in 1981 (see table below). Corn rootworms maintained their position as the third most important insect pest, while the European corn borer dropped from second in 1981 to fifth this year. Posting perhaps the greatest increase in importance were wireworms, going from an unrated status in 1981 to the sixth most important insect pest in 1982. Additionally, Illinois's two major alfalfa pests, the alfalfa weevil and particularly the potato leafhopper, were also perceived as having increased importance this year.

Agricultural	Rank according to number of inquiries reported	Nonagricultural
cutworms	1	tree & shrub insects
potato leafhopper	2	white grubs
corn rootworms	3	garden insects
alfalfa weevil	4	pantry insects
European corn borer	5	mosquitoes
wireworms	6	flies and gnats
bean leaf beetle	7	termites
aphids	8	roaches
stored grain insects	9	fleas
fall armyworm	10	picnic beetle

Overall, as estimated from the reports of Extension advisers, a total of 6,507,000 acres of major field crops was treated with insecticides. This total is a reduction of nearly 10 percent from last year's figure, which in turn represented a 10 percent reduction from 1980. The most substantial decrease in insecticide application was a 32 percent drop in the acreage that was rescue treated for cutworms. Significant reductions in acreage treated for armyworms were also noted.

Cutworms

Information provided by county advisers determined the "most unwanted" insect of 1982 to be the black cutworm. An estimated 406,000 acres of corn were emergency treated for cutworms, and approximately 63,000 acres were replanted because of cutworm damage. Although cutworms were the number-one problem this year and last, the figures above are significantly lower than last year's estimates (Table 1), again a testament to a year of relative quiet on the insect front.

Indeed, most growers breathed a sigh of relief this year as the near-record incidence of cutworm problems experienced in 1981 did not recur in 1982. Although some damage was reported, primarily in southern and western Illinois, it was light to moderate in comparison with that of last year. Nevertheless, damage from cutworms was perhaps the single most important insect problem in 1982.

Control of cutworms may require the application of a preplant or at-planting soil insecticide, although treatment at this time is often unnecessary since serious cutworm infestations are sporadic and difficult to predict. The chances of cutworm damage are greater in late planted, reduced tillage, and weedy fields. The most economical method of control involves field scouting as plants begin to emerge. From this scouting, the need for a rescue treatment can be assessed.

Potato Leafhopper

Economic numbers of potato leafhoppers again infested numerous alfalfa fields statewide. Many fields incurred considerable feeding damage in the form of stunting and nutrient loss. An estimated 116,000 acres of alfalfa were treated for potato leafhopper, the only alfalfa insect for which more acreage was treated in 1982 than in 1981. In addition to posting a nearly 10 percent increase in acreage treated, potato leafhoppers ranked behind cutworms as the second most important insect pest of the year.

Feeding on the undersides of leaves, potato leafhoppers cause injury by sucking plant juices and releasing a substance toxic to the plant. The result is "hopper burn," a V-shaped yellowing of the leaves beginning at the tips.

Alfalfa stands should be checked for leafhoppers, particularly after the first cutting, as damage is most often seen in the second and third growth stages. When leafhoppers are numerous, a portion of the field can be cut a few days before the rest. The leafhoppers tend to migrate from the freshly cut plants to the uncut portion of the field. After this migration, the leafhoppers are concentrated and can be more effectively controlled with insecticides.

Potato leafhopper numbers are difficult to predict since the species does not overwinter in Illinois. Each year these insects, like several other species including cutworms, migrate into the state aided by storm fronts and accompanying high winds. Thus, the potential for leafhopper problems always exists, and it does seem likely that the potato leafhopper will again threaten many Illinois alfalfa fields in 1983.

Corn Rootworms

Advisers ranked corn rootworms third on their list of important insects in 1981 and again in 1982. However, results of this year's corn rootworm beetle survey (Table 2) indicate a dramatic reduction in the Illinois rootworm population. Heavy rains figured prominently in depressing rootworm numbers, and, by encouraging rapid root regeneration, the rains masked the damage done by surviving larvae.

The annual survey also shows a rough equivalence between populations of the northern and western rootworm species in the upper two-thirds of the state. In the southern quarter of Illinois, western rootworms outnumbered northern rootworms nearly five to one, and the number of southern corn rootworms rivaled that of the northern and western species combined. The southern corn rootworm is not known to overwinter in Illinois, however, and damage from the larvae of this insect is extremely rare.

On the whole, very few fields were treated for rootworm beetle damage to silks, as fields with economic numbers of beetles (five or more beetles per plant) were rare. The potential for rootworm problems next year should be minimal in virtually all areas of the state (Figure 1). Use of soil insecticides may be advisable in continuous cornfields, but only if an average of one or more beetles per plant was recorded in such fields the previous summer. The use of rootworm insecticides in first-year corn is not recommended.

Alfalfa Weevil

Alfalfa stands experienced a mild year in terms of alfalfa weevil infestation. Some economic injury did occur in southern Illinois, but little damage was reported elsewhere. Overall, the alfalfa weevil was rated the fourth most important insect of the year, and, in comparison with last year's figure, insecticide use against alfalfa weevils was down approximately 20 percent.

In contrast to injury caused by the potato leafhopper, most alfalfa weevil damage is done to first-growth alfalfa, that is, prior to the first cutting. The larvae are primarily responsible for this damage.

Warm, snowy winters are conducive to the weevil's overwintering capacity, and warm, dry spring weather (contrary to the cool, wet weather of spring 1982) can bring about an upsurge in weevil activity. Alfalfa stands should be monitored closely under such conditions.

European Corn Borer

Again, the spring rains drastically affected the population of yet another insect, the European corn borer. Wind and driving rains hindered egg-laying flights of adult moths and repeatedly filled the upper whorls of corn where the larvae feed, resulting in high larval mortality. This mortality is evidenced by the findings of the annual spring survey of first-generation borers; a statewide average of only two borers per 100 plants was recorded—the lowest figure in five years (Table 3).

Despite these early indications of a decline in the corn borer population, an estimated 223,000 acres were treated for European corn borer, a figure almost exactly matching that of last year, a year when corn borer numbers were considerably higher.

The ensuing population of second-generation borers was similarly low according to results of the annual fall survey, with an average of only 26 borers per 100 stalks. This average was the lowest second-generation population the state has seen for over thirty years. Reflecting this decline, the European corn borer dropped from its rating of the second most important pest of 1981, to fifth in 1982.

In terms of the corn borer problems experienced in 1982, 1983 promises to be a light year (Figure 2). Fields should be scouted in late spring and may warrant treatment if 50 percent or more of the plants show signs of fresh whorl feeding and if larvae are present. For second-generation borers, scout in midsummer for egg masses on the undersides of leaves. Treatment is usually advisable when egg masses can be found on 50 percent or more of the plants in a field. Early planting is advisable since late planted fields are particularly attractive to the egg-laying moths.

Wireworms

Not considered a serious problem in 1981, wireworms became the state's sixth most important insect pest of 1982. As previously mentioned, the new status of wireworms may be due in part to the year's relative lack of major insect problems. Nevertheless, the cool, wet conditions of spring favored the feeding larvae, and county advisers placed greater significance on wireworms than on several other ranking corn insects, for example, corn leaf aphids and armyworms.

Even though damage from wireworms may have shown an increase in 1982, application of soil insecticides in 1983 will not be justified in most cases for control of wireworms alone. Seed treatment, ample drainage of fields, and weed control help to reduce the risk of wireworm damage. Crop rotation, on the other hand, is largely ineffective in preventing wireworm infestations.

Bean Leaf Beetle

Spring precipitation also influenced bean leaf beetle numbers. Heavy rainfalls during the beetle's reproductive period led to decreased survival among newly hatched larvae. Both early season seedling damage and late season injury to pods were minimal.

The number-one insect pest in Illinois soybeans, the bean leaf beetle was rated only seventh in overall importance in 1982, down from sixth place in 1981. An estimated 42,000 acres of soybeans were treated for bean leaf beetles, again down from last year's total by approximately 18 percent.

In 1983, consider treatment of prebloom soybeans only when defoliation reaches 30 percent or when defoliation exceeds 15 percent during bloom and pod-fill stages.

Corn Leaf Aphid

Acreage treated for corn leaf aphids more than doubled in 1982 according to estimates from reporting county advisers. Colonies of corn leaf aphids were apparent on corn over most of the state, but heavy infestations were the exception and were, for the most part, confined to southern Illinois.

Each year these aphids fly and are blown into Illinois from the south. Crop scouting is the first line of defense against them, as the extent of their presence in Illinois is unpredictable.

Corn leaf aphids generally infest the upper whorls and tassels of corn. Like leafhoppers, aphids suck plant juices and, in sufficient numbers, can cause economic injury to corn experiencing moisture stress. The aphids also exude a sticky substance that can interfere with corn pollination.

Fall Armyworm

Although the fall armyworm rated tenth on the county advisers' list, estimates reveal that acreage treated for this insect was considerably less in 1982 than the year before, when, in contrast, it did not make the top ten pest list. Such statistics may appear contradictory, but they can be explained by considering the relative lack of severe insect infestations this year. A total of 48,000 acres were treated for fall armyworm in 1981 in comparison with 15,000 in 1982, a reduction of 68 percent.

A nuisance particularly in late planted corn, fall armyworms tend to feed deep in the upper whorls of leaves, doing considerable damage and leaving the plant with a rather ragged appearance. Fall armyworms may also cause injury to the developing tassels and ears.

Beginning in midsummer, fall armyworm moths enter Illinois from the southern states. For this reason, future populations are difficult to estimate. Frequent scouting starting in midsummer is especially important as effective use of insecticides requires that the armyworms be treated in their early stages of growth.

Common Stalk Borer

Common stalk borers were a serious problem in some Illinois cornfields. The adult moths typically lay eggs in grasses and weeds such as ragweed. The eggs hatch in spring, and larvae begin feeding by boring into the stems of these plants. Stalk borer larvae grow up to two inches in length, and in so doing require increasingly larger host plants. Often the borers will infiltrate neighboring cornfields, doing extensive damage to border rows. However, this year, as in 1981, stalk borer damage was seen throughout some reduced- and no-till fields. Weedy cornfields and no-till fields have been particularly susceptible, especially in the northern third of the state.

Hessian Fly

Perhaps of great significance is this year's substantial increase in the Hessian fly population. Hessian fly numbers are up nearly 60 percent over last year's figures, according to ARS-USDA, Purdue University, and the Illinois Crop Improvement Association.

Reasons for the upsurge in Hessian fly numbers include (1) wet spring weather conducive to fly reproduction, (2) the acquired ability of some Hessian flies to live on previously resistant varieties of wheat, and (3) the seeding of wheat prior to fly-free dates.

Hessian flies deposit eggs in spring on the leaves of wheat and occasionally on other small grains such as barley and rye. The larvae hatch and suck sap from the stem before pupating there and later emerging as adult flies. Infested stems usually break under the weight of developing grain heads. Crop yield can be greatly reduced.

If current trends continue, an even larger Hessian fly population can be expected in 1983. To minimize damage, destroy volunteer wheat, seed after the fly-free date, and plant currently resistant varieties such as Auburn and Caldwell.

Mexican Bean Beetle

The occurrence of a locally heavy infestation of Mexican bean beetle is one of the most disquieting events in what was a reasonably quiet year of insect management. For the Mexican bean beetle, 1982 was indeed a landmark year as Illinois recorded its first incidence of severe soybean defoliation attributed to this insect.

For a number of years the Mexican bean beetle has been an occasional pest of lima, snap, pinto, and kidney beans in gardens throughout the state. And until this year, only a small number of beetles had been observed in soybean fields, primarily in counties along the Indiana border. It now appears that the Mexican bean beetle may be fairly common in that area of the state and that the population may be expanding.

Both the adult beetles and the rather odd-looking larvae normally feed on the undersides of leaves. Like the larvae, the pupae are bright yellow, hard-bodied, oval-shaped insects about one-third inch long. Heavy infestations of Mexican bean beetle in soybeans give fields a dusty appearance as the skeletonized leaves turn brown and wither. Such defoliation may occur early in the season or late in the bloom and pod-set stages of development. In these latter stages, the economic threshold for treatment is defined as 17 or more beetles (adult + larvae + pupae) per meter of bean plants in a row. Illinois soybean fields, especially those double cropped with wheat, should be closely monitored throughout the growing season next year since the potential for economic damage exists.

Table 1. Illinois Acreage Treated with Insecticides, 1981 to 1982

Crop and insect	Acres treated (rounded to nearest 1000) 1982	1981
Corn		
Soil insects (cutworms, rootworms, etc.)	5,486,000	5,737,000
Cutworms (emergency treatment only)	406,000	596,000
European corn borer	223,000	222,000
Corn leaf aphid	16,000	7,000
Fall armyworm	15,000	48,000
Common stalk borer	13,000	-
Grasshoppers	9,000	2,000
True armyworm	7,000	62,000
Corn flea beetles	2,000	9,000
Corn rootworms (adults)	-	54,000
TOTAL	6,177,000	6,737,000
Soybeans		
Bean leaf beetle	42,000	51,000
Green cloverworm	12,000	0
Grasshoppers	5,000	15,000
Spider mites	3,000	1,000
TOTAL	62,000	67,000
Alfalfa		
Alfalfa weevil	127,000	161,000
Potato leafhopper	116,000	105,000
Grasshoppers	15,000	15,000
Pea aphid	2,000	-
Variegated cutworm	1,000	1,000
TOTAL	261,000	282,000
Sorghum		
All insects (primarily sorghum midge)	7,000	7,000
TOTAL	6,507,000	7,093,000

Table 2. Abundance of Adult Northern and Western Corn Rootworm Beetles in Illinois, 1977 to 1982

District and county	Average number of rootworm beetles per plant[a]					
	1977	1978	1979	1980	1981	1982
Northwest						
Bureau	3.63	1.04	2.10	2.71	3.42	0.40
Lee	3.55	0.54	1.19	3.18	0.69	0.23
Mercer	2.73	0.69	4.02	0.93	1.39	0.03
Ogle	2.49	1.59	1.02	3.90	1.73	0.76
Stephenson	5.62	1.00	2.41	4.02	1.60	0.30
Whiteside	3.45	1.12	1.83	1.98	0.51	0.22
AVERAGE	3.58	0.99	2.10	2.79	1.56	0.32
Northeast						
Boone	3.31	1.25	0.75	4.52	5.91	0.40
DeKalb	1.94	1.78	0.56	4.91	3.46	0.14
LaSalle	3.68	0.96	1.21	3.30	2.68	0.44
AVERAGE	2.98	1.32	0.84	4.24	4.02	0.32
West						
Adams	1.46	0.29	0.61	1.07	0.27	0.08
Henderson	2.59	0.64	1.30	0.44	1.28	0.16
Knox	2.32	0.99	1.17	0.58	2.51	0.11
McDonough	1.90	0.42	0.44	0.67	0.48	0.23
Warren	2.48	0.85	2.09	1.51	1.29	0.07
AVERAGE	2.15	0.64	1.12	0.85	1.17	0.13
Central						
Logan	0.96	1.94	1.56	2.23	0.98	0.19
McLean	2.82	0.89	1.35	1.57	0.85	0.47
Peoria	2.18	1.10	1.10	3.56	1.49	0.41
Woodford	2.80	1.97	3.14	3.76	2.01	1.39
AVERAGE	2.19	1.47	1.79	2.78	1.33	0.61
East						
Champaign	1.63	0.36	2.08	2.39	0.85	0.77
Iroquois	2.25	0.16	0.41	0.53	0.89	0.55
Kankakee	2.80	0.16	0.74	3.67	1.98	0.72
Livingston	3.22	1.93	1.09	3.83	1.72	0.92
Vermilion	3.22	1.24	0.45	0.84	1.17	0.99
AVERAGE	2.62	0.77	0.95	2.25	1.32	0.79
West-southwest						
Christian	0.61	0.10	0.35	0.47	1.30	0.04
Greene	1.50	0.12	0.77	2.72	0.26	0.34
Macoupin	0.77	0.09	0.46	0.79	0.19	0.20
Montgomery	0.09	0.34	0.98	1.29	0.41	0.01
Morgan	0.71	0.09	0.07	2.12	0.22	0.11
AVERAGE	0.74	0.15	0.53	1.48	0.48	0.14

Table 2. (Continued)

District and county	Average number of rootworm beetles per plant[a]					
	1977	1978	1979	1980	1981	1982
East-southeast						
Clark	0.19	0.27	0.34	2.25	0.78	0.68
Jasper	0.05	0.16	0.22	1.17	0.73	0.09
Marion	0.03	0	0.15	0.23	0.10	0.01
Shelby	0.29	0	0.36	2.02	0.82	0.01
AVERAGE	0.14	0.11	0.27	1.42	0.61	0.20
Southwest						
Randolph	0.36	0.03	0.04	0.91	0.01	0.03
St. Clair	0	0.01	0.05	0.05	0.07	0.03
Union	0	0.01	0.03	0	0	0.01
Washington	0	0.03	0.04	0.13	0.07	0.00
AVERAGE	0.09	0.02	0.04	0.27	0.04	0.02
Southeast						
Franklin	0	0	0.71	0.04	0.01	0.01
Gallatin	0.03	0.12	0.25	0.46	0.27	0.07
Wabash	-	-	0.16	0.70	1.25	0.05
Wayne	0.02	0	0.04	0.08	0.43	0.05
White	0	0.01	0.06	0.08	0.14	0.11
AVERAGE	0.01	0.03	0.24	0.27	0.42	0.06
STATE	1.69	0.61	0.92	1.75	1.13	0.29

[a]Counts include western and northern species present on leaves, stalk, tassels, and one ear per plant.

Table 3. First- and Second-Generation European Corn Borer Populations in Illinois, 1981 to 1982

District and county	Number of borers per 100 plants			
	1982		1981	
	First generation	Second generation	First generation	Second generation
Northwest				
Bureau	0	9	31	109
Jo Daviess	-	27	-	114
Mercer	2	26	39	154
Ogle	0	20	25	131
Whiteside	0	21	39	135
Winnebago	-	37	-	121
AVERAGE	0	23	34	127
Northeast				
DeKalb	0	1	25	118
LaSalle	3	0	16	60
McHenry	0	0	44	136
AVERAGE	1	0	28	105

Table 3. (Continued)

District and county	Number of borers per 100 plants: 1982 First generation	1982 Second generation	1981 First generation	1981 Second generation
West				
Adams	5	29	43	62
Brown-Cass	-	17	-	21
Henderson	-	14	-	116
Knox	1	8	47	71
McDonough	2	18	24	77
AVERAGE	3	17	38	69
Central				
Logan	2	24	24	169
Macon	-	11	-	112
McLean	2	30	29	81
Woodford	1	81	4	50
AVERAGE	2	37	19	103
East				
Champaign	0	81	15	17
Iroquois	2	14	4	63
Kankakee	0	3	16	74
Livingston	1	22	13	59
Vermilion	-	27	-	13
AVERAGE	1	29	9	45
West-southwest				
Christian	1	59	6	78
Greene	2	21	16	106
Madison	4	52	35	282
Sangamon	1	25	7	14
AVERAGE	2	39	16	120
East-southeast				
Clark	1	15	56	22
Effingham	4	38	100	145
Jasper	0	71	161	70
Marion	5	105	54	357
Moultrie	-	14	-	45
AVERAGE	2	49	93	128
Southwest				
Jackson	2	2	40	65
Alexander-Pulaski	0	0	16	30
Randolph	1	-	28	-
St. Clair	2	86	36	156
Washington	2	9	62	233
AVERAGE	1	24	36	121

Table 3. (Continued)

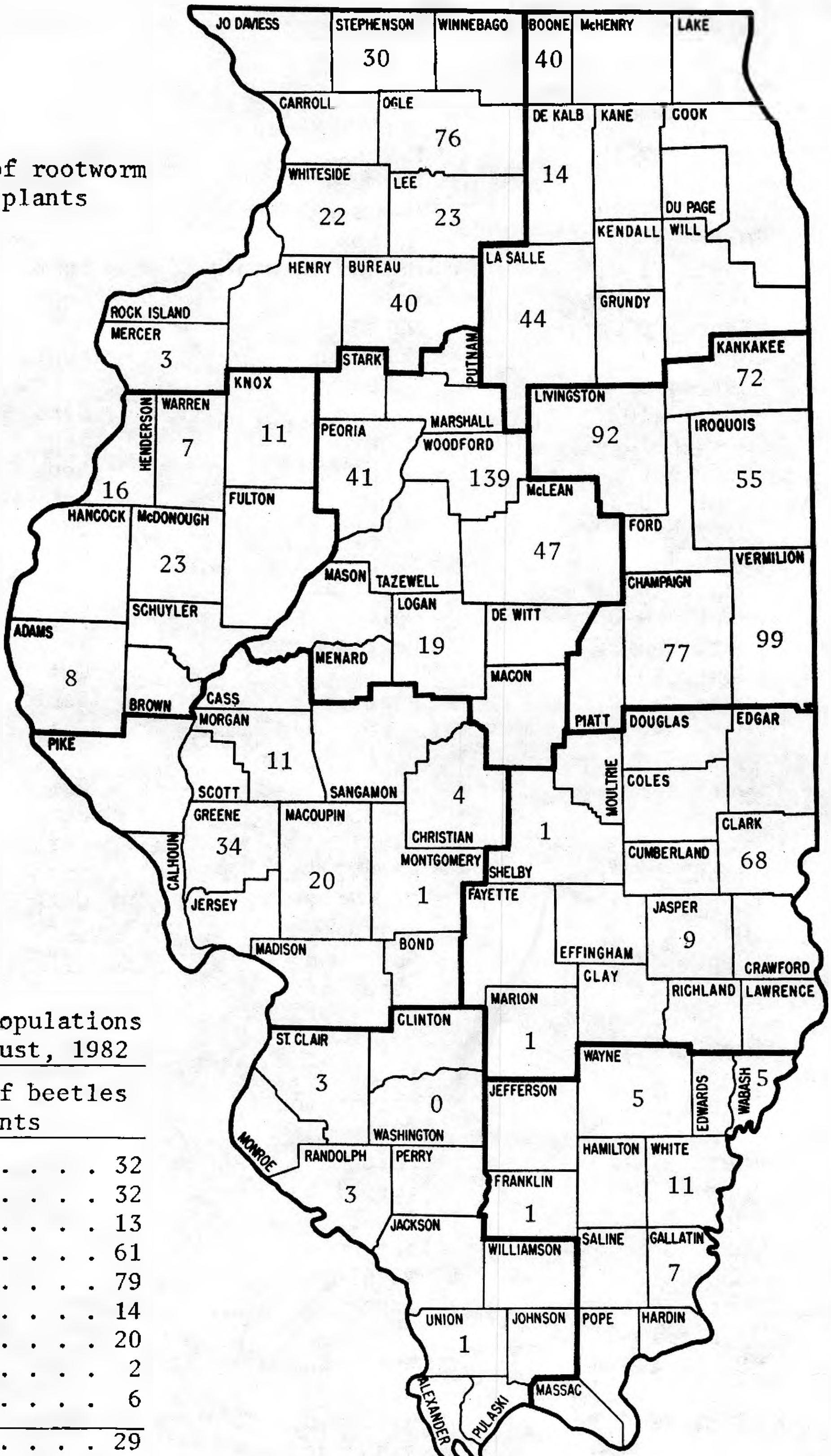
District and county	Number of borers per 100 plants			
	1982		1981	
	First generation	Second generation	First generation	Second generation
Southeast				
Edwards	4	-	51	-
Franklin	2	1	47	46
Massac	1	-	8	-
Saline	2	3	14	98
Wayne	-	8	-	120
White	2	3	46	95
AVERAGE	2	4	33	90
STATE	2	26	32	101

Table 4. Average Date of Seeding Wheat for Highest Yield in Illinois Counties

County	Average date	County	Average date
Adams	Sept. 30-Oct. 3	Lee	Sept. 19-21
Alexander	Oct. 12	Livingston	Sept. 23-25
Bond	Oct. 7-9	Logan	Sept. 29-Oct. 3
Boone	Sept. 17-19	Macon	Oct. 1-3
Brown	Sept. 30-Oct. 2	Macoupin	Oct. 4-7
Bureau	Sept. 21-24	Madison	Oct. 7-9
Calhoun	Oct 4-8	Marion	Oct. 8-10
Carroll	Sept. 19-21	Marshall-Putnam	Sept. 23-26
Cass	Sept. 30-Oct. 2	Mason	Sept. 29-Oct. 1
Champaign	Sept. 29-Oct. 2	Massac	Oct. 11-12
Christian	Oct. 2-4	McDonough	Sept. 29-Oct. 1
Clark	Oct. 4-6	McHenry	Sept. 17-20
Clay	Oct. 7-10	McLean	Sept. 27-Oct. 1
Clinton	Oct. 8-10	Menard	Sept. 30-Oct. 2
Coles	Oct. 3-5	Mercer	Sept. 22-25
Cook	Sept. 19-22	Monroe	Oct. 9-11
Crawford	Oct. 6-8	Montgomery	Oct. 4-7
Cumberland	Oct. 4-5	Morgan	Oct. 2-4
DeKalb	Sept. 19-21	Moultrie	Oct. 2-4
DeWitt	Sept. 29-Oct. 1	Ogle	Sept. 19-21
Douglas	Oct. 2-3	Peoria	Sept. 23-28
DuPage	Sept. 19-21	Perry	Oct. 10-11
Edgar	Oct. 2-4	Piatt	Sept. 29-Oct. 2
Edwards	Oct. 9-10	Pike	Oct. 2-4
Effingham	Oct. 5-8	Pope	Oct. 11-12
Fayette	Oct. 4-8	Pulaski	Oct. 11-12
Ford	Sept. 23-29	Randolph	Oct. 9-11
Franklin	Oct. 10-12	Richland	Oct. 8-10
Fulton	Sept. 27-30	Rock Island	Sept. 20-22
Gallatin	Oct. 11-12	St. Clair	Oct. 9-11
Greene	Oct. 4-7	Saline	Oct. 11-12
Grundy	Sept. 22-24	Sangamon	Oct. 1-5
Hamilton	Oct. 10-11	Schuyler	Sept. 29-Oct. 1
Hancock	Sept. 27-30	Scott	Oct. 2-4
Hardin	Oct. 11-12	Shelby	Oct. 3-5
Henderson	Sept. 23-28	Stark	Sept. 23-25
Henry	Sept. 21-23	Stephenson	Sept. 17-20
Iroquois	Sept. 24-29	Tazewell	Sept. 27-Oct. 1
Jackson	Oct. 11-12	Union	Oct. 11-12
Jasper	Oct. 6-8	Vermilion	Sept. 28-Oct. 2
Jefferson	Oct. 9-11	Wabash	Oct. 9-11
Jersey	Oct. 6-8	Warren	Sept. 23-27
Jo Daviess	Sept. 17-20	Washington	Oct. 9-11
Johnson	Oct. 10-12	Wayne	Oct. 9-11
Kane	Sept. 19-21	White	Oct. 9-11
Kankakee	Sept. 22-25	Whiteside	Sept. 20-22
Kendall	Sept. 20-22	Will	Sept. 21-24
Knox	Sept. 23-27	Williamson	Oct. 11-12
Lake	Sept. 17-20	Winnebago	Sept. 17-20
LaSalle	Sept. 19-24	Woodford	Sept. 26-28
Lawrence	Oct. 8-10		

Figure 1. Western and northern corn rootworm prospects, 1983.

Average number of rootworm beetles per 100 plants

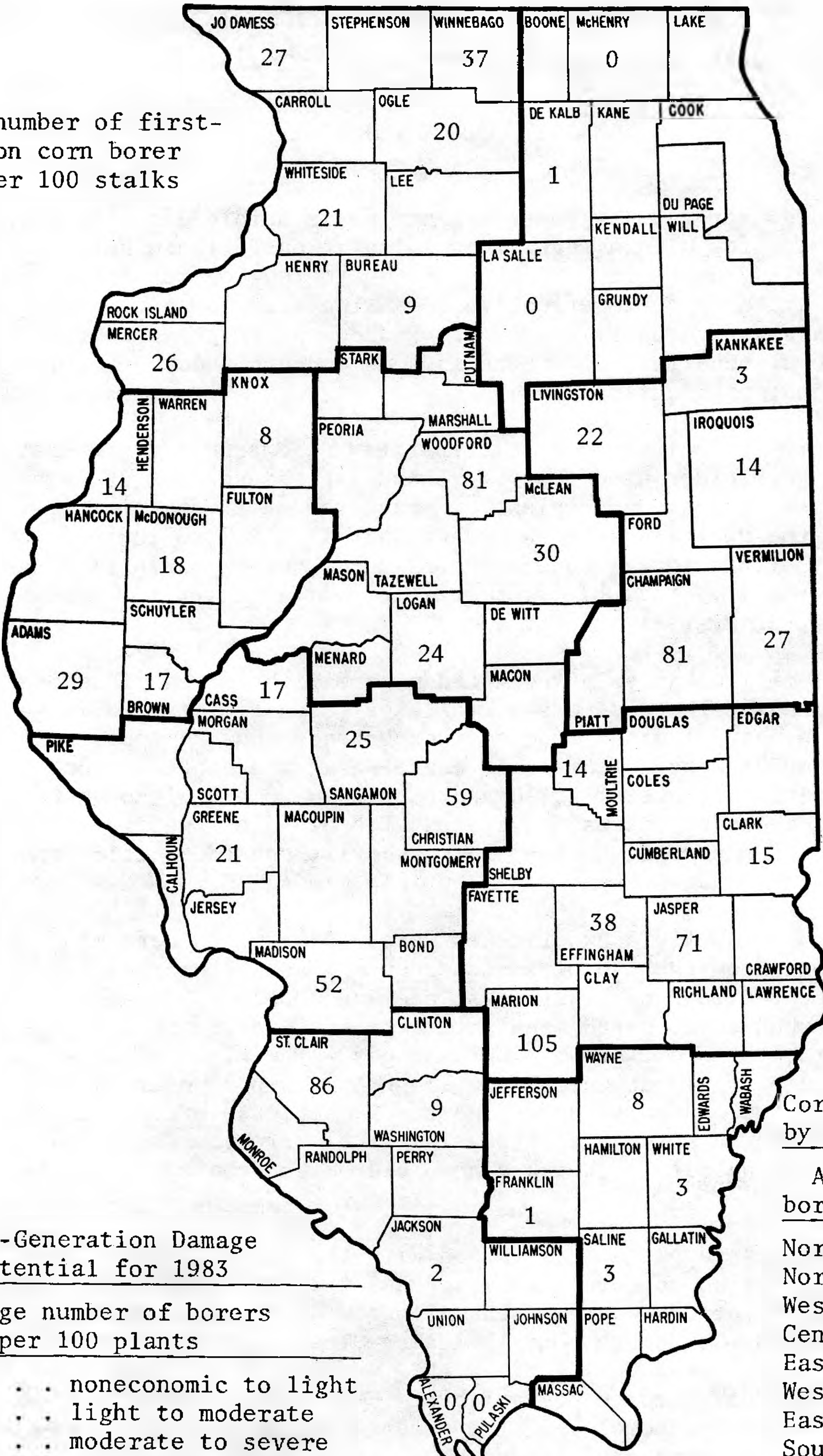


Adult Rootworm Populations by District, August, 1982

Average number of beetles per 100 plants	
Northwest	32
Northeast	32
West	13
Central	61
East	79
West-southwest	14
East-southeast	20
Southwest	2
Southeast	6
STATE	29

Figure 2. European corn borer prospects for 1983.

Average number of first-generation corn borer larvae per 100 stalks



Corn Borer Populations by District, Fall, 1982

Average number of borers per 100 stalks	
Northeast	23
Northwest	0
West	17
Central	37
East	29
West-southwest . .	39
East-southeast . .	49
Southwest	24
Southeast	4
STATE	26

First-Generation Damage Potential for 1983

Average number of borers per 100 plants	
0-100	noneconomic to light
100-250	light to moderate
250 or more . .	moderate to severe

Potential Drift Damage from Postemergence Herbicides for Grass Control in Soybeans

J.P. Chernicky

In the near future, several new postemergence grass herbicides will receive full market registration for use in several broadleaf crops. These herbicides are quite effective on annual grasses in the range of two to four ounces of active ingredient per acre. They are also quite effective on a wide array of perennial grasses, although higher rates are usually required. Postemergence grass control provides the grower with several benefits, but there is some concern about potential injury to nearby grass crops, particularly corn.

Benefits to the grower include (1) an alternative to the standard preplant-incorporated or preemergence herbicides used today for annual grass control in soybeans, (2) a "back-up" treatment in case a preplant or preemergence treatment fails, and (3) the option of using the "wait-and-see" approach that is utilized in integrated pest management systems. (This latter benefit is slightly questionable since annual grass populations are not that variable from year to year.) Given these benefits. what concerns are associated with their use?

Approximately 11 million acres of corn and nine million acres of soybeans are grown annually in Illinois. That is to say, for every corn field there is an adjacent soybean field. We have learned from past experience that an application of a herbicide in one crop has the potential to cause damage to another crop. Our historical example involves the use of 2,4-D and banvel in corn. Although these treatments are effective in reducing losses associated with broadleaf weed competition in corn, spray particles and vapors have been shown to drift considerable distances on windy days and sometimes to damage nearby susceptible crops.

In 1982, greenhouse and field experiments were conducted to determine the potential for damage to corn from the use of postemergence grass herbicides in soybeans. Extremely low concentrations of Poast, Fusilade, and Dowco 453--ranging from four to 270 times lower than anticipated manufacturers' recommended rates--were applied topically to corn at two different growth stages. The highest rates chosen were based on greenhouse trials at which only slightly visible injury was detected. Additional rates were chosen to determine the "visible no-effect" level, which does not necessarily mean an absence of a physiological effect. These low rates were chosen to simulate the rate at which a herbicide might contact a plant under drift conditions.

Corn response to these applications varied with the herbicide and the growth stage of corn. An application to corn 6 to 16 inches tall resulted in the greatest visible damage; however, the effect was not season long. Application to 28- to 32-inch corn resulted in less visible damage, but the damage that occurred lasted much longer.

Visible injury symptoms were quite variable. Corn sprayed with Fusilade and Dowco 453 exhibited similar symptomology. The treated leaves tended to have a slight, localized, bleached appearance followed by abnormal unrolling of the corn leaf.

Poast, in comparison, severely bleached the younger leaves, followed by cessation of the meristematic region. On a pound-for-pound basis, Fusilade was the most active on corn, followed by Dowco 453, then by Poast. This ranking may not hold true, however, once the yield data is analyzed and the work is repeated in 1983.

Generally, this one-year study indicates that injury to corn in nearby fields is relatively unlikely if postemergence grass killers are applied with reasonable care.

1982 Update on Soybean Diseases

B.J. Jacobsen

Soybean diseases were major factors in reducing potential soybean yields in 1982. Diseases that caused significant yield losses included Phytophthora root rot, Septoria brown spot, soybean cyst nematode, brown stem rot, anthracnose pod and stem blight, and charcoal rot. In general, 1982 was an excellent year to evaluate new varieties resistant to soybean cyst nematodes, new seed treatment fungicides for control of Pythium and Phytophthora root rots, and fungicides for control of Septoria brown spot and pod and stem blight disease.

Soybean Cyst Nematode

Damage from soybean cyst nematodes was dramatic in 1982, and the nematode was identified for the first time in Edwards, Fulton, and Christian counties. Damage in southern Illinois was particularly dramatic because soils warmed up early, allowing early development of populations, and because dry conditions after mid-July caused damage to the root systems to be more apparent than if conditions had remained wet.

New controls for soybean cyst nematodes became available in 1982. These include the state registration for Temik 15G to be used in-furrow at seven pounds per acre and the federal registration of Furadan 10G as a banded application. For a comparison of the efficacy of these new registrations, see *Report on Plant Diseases* (RPD) 501 in the disease reference section at the back of this manual. The new Temik registration appears to be as effective as the 14 to 20 pound rate applied in a band. Thus, only half as much nematicide is used at only half the cost. At this time, we still recommend the use of a nematicide only where resistant varieties are not adapted or usable or where rotation is not feasible.

The new resistant variety Fayette will be available to growers in 1983. This variety is similar to Williams but is resistant to races three and four of soybean cyst nematode. Yields of Fayette, Franklin, and other varieties in the presence and absence of the nematode are compared in Tables 1 and 2.

Fayette is the first soybean-cyst-nematode-resistant variety that has yield potentials nearly equal to high-yielding varieties in the absence of the nematode. This variety represents nearly 25 years of breeding and soybean cyst nematode research. Growers should be sure to use rotation whenever using this or any other resistant varieties since, without rotation, races that can attack the race-specific resistance will build up rapidly. Research and observations indicate that damaging levels of new races will build up after two to four years of continuous cropping to a resistant variety. We have not observed this buildup where rotations with nonhost crops are involved.

For further information on soybean cyst nematode, see RPD 501.

Phytophthora Root Rot

Damage from Phytophthora root rot was widespread and serious in some areas. Damage from races other than one or two is evidenced by widespread reports of damage to varieties such as Amsoy 71, Wells, Wells II, Corsoy 79, and Beeson 80. One case of Phytophthora root rot was confirmed on Williams 82, a variety resistant to races one through nine.

In Southern Illinois, damage was often seen in combination with soybean cyst nematodes. Research at the University of Illinois has shown that damage from both pathogens interacting together is greater than from the sum of either organism alone.

The high incidence of Phytophthora root rot offered an excellent opportunity to evaluate the two new fungicides Grandstand (Dow) and Apron (Ciba Giegy), which have shown promise for control of this disease. See the paper by Dr. H.W. Kirby for a more detailed report on this research.

To date, the Apron and Grandstand seed treatments appear to give good to excellent control of the seedling blight phase of Phytophthora root rot. Control beyond the seedling blight stage has been seen where Ridomil (Ciba-Giegy) granules have been used at planting. In fact, yields indicate that granular Ridomil treatments are consistently better than seed treatment applications of either Apron or Grandstand.

Brown Stem Rot

Damage from brown stem rot was widespread in areas north of Interstate 70, with the disease becoming more important in northern Illinois. Dry weather in August increased losses. At the present time, control can be achieved by crop rotations of three years or more in a nonhost crop such as corn. Recent research at Iowa State University reports that resistant soybean varieties such as BSR301 or 302 can be used in rotations as effectively as corn. Thus, by utilizing one of the resistant varieties, growers can maintain a corn-soybean rotation. For example, in the year after brown stem rot damage is noticed, plant corn; in the next year, plant a brown-stem-rot-resistant variety; in the third year of the rotation, plant corn; after the third year, any soybean variety can be used.

In addition to the BSR301 and 302 lines, a maturity group II line BSR201 has been released. It should be available to commercial growers in 1984.

Charcoal Rot

Charcoal rot damage was serious throughout southern Illinois. Growers should remember to plant heavily infested fields early with full-season varieties and to make sure that pH, potash, and phosphorus are at optimal levels. There are no resistant varieties, and only crop rotation with wheat has been shown to be helpful in control. Corn, sorghum, clover, and alfalfa do not appear to be useful in rotations for control of this disease.

Research by Dr. Tom Wyllie at the University of Missouri indicates that disease severity may be predicted by soil sampling. We hope to evaluate these techniques for prediction under Illinois conditions in 1983.

Septoria Brown Spot, Purple Seed Stain, Pod and Stem Blight, and Anthracnose

Dry conditions during August limited these diseases to a degree, but wet conditions in September allowed considerable disease development. In research plots at Tolono, Illinois, fungicide sprays increased yields by 4 to 4.5 bushels per acre where two applications were made.

In late September state section 24C labels were granted for single applications of Benlate and Mertect 340 F. These single applications are made to improve seed quality. Research done during this and previous years has shown, however, that single applications do not increase yields as greatly as two applications. Single applications will save only the cost of a second application but not chemical cost since higher labeled rates are suggested for single applications. Because yields are not as great as with the previously labeled double application and seed quality increases are no better, these new single applications are useful mainly as insurance against poor seed quality where delayed harvests may occur or where earlier applications were not made.

Table 1. Comparison of Yields of Soybean Varieties Resistant and Susceptible to Soybean Cyst Nematode in Illinois[a]

	Yield in locations infested with soybean cyst nematodes			Yield in locations not infested with soybean cyst nematodes		
Variety	Yale, Jasper Co.	Mt. Vernon, Jefferson Co.	Sidney, Champaign Co.	Eldorado, Gallatin Co.	Belleville, St. Clair Co.	Urbana, Champaign Co.
			bushels per acre			
Williams 82	9.5	25.8	--	48.4	56.4	51.3
Cumberland	5.6	30.6	--	50.6	57.5	56.3
Pella	8.1	23.1	--	50.2	55.7	53.1
Century	4.2	--	--	45.9	49.3	56.1
Union	15.5	29.2	--	50.9	--	--
Fayette	31.7	34.8	52.0	46.5	50.8	50.2
Franklin	26.0	30.6	--	42.0	--	--
Wells II	--	--	44.7			
Williams 79	--	--	44.6			

[a]Data from Dr. R.L. Bernard, Dr. G.R. Noel, and Dr. D.I. Edwards. USDA, 1981.

Table 2. Yield of Fayette, Williams 82, and Franklin Soybeans in 1982 County Demonstration Plots in Illinois

Variety	Yield (bu./A)	Range (bu./A)	Number of plots
Fayette[a]	48.9	31.9 - 51.6	15
Williams 82[b]	47.5	34.7 - 55.9	16
Franklin[c]	46.5	33.7 - 55.8	8

[a]Maturity group III resistant to races three and four of soybean cyst nematode. Yield data from plots in Clay, Crawford, Franklin, Gallatin, Grundy, Iroquois, LaSalle, Mercer, Monroe, Piatt, Richland, St. Clair, Washington, and White counties.

[b]Maturity group III susceptible to soybean cyst nematode. Yield data from plots in Clay, Crawford, Franklin, Gallatin, Grundy, Iroquois, LaSalle, Mercer, Monroe, Piatt, Richland, St. Clair, Washington, and White counties.

[c]Maturity group IV resistant to race three of soybean cyst nematode. Yield data from plots in Clay, Franklin, Gallatin, St. Clair, White, and Washington counties.

Experimental Insecticides for European Corn Borer

E. Levine

The European corn borer can be a serious pest of field corn in Illinois. In 1982 we evaluated nine experimental foliar insecticides for their control of first-generation larvae. We also included the registered compound Furadan 15G for comparison. This study was conducted at the Agronomy South Farm of the University of Illinois in Champaign.

Corn (Pioneer 3780) was planted in 30-inch rows on May 14. Each plant in the study was artificially infested with approximately 30 freshly hatched larvae on June 22 and again on June 23 and 24. The mean extended leaf height of these plants on June 24 was 46 inches. Insecticides were applied on June 30, just as the larvae were beginning to tunnel into the plants. Liquid insecticides were applied directly over the plant whorls with a CO_2 back-pack sprayer equipped with a one nozzle wand (even flat-fan nozzle, 4.0 ft./sec., 20 psi, 0.14 gal./min., 10 gal. of water/acre). Granular insecticides were applied in a 7-inch band directly over the plant whorls with Noble metering units mounted on a tractor.

Each treatment consisted of a single, 25-foot-long row. Experiments were arranged in a randomized, complete-block design with four replications per treatment. Uninfested rows bounded each treatment row; plants in these border rows were cut down one day prior to insecticide application to facilitate access of the granular applicator. The insecticide-treated plants were evaluated for corn borer damage (number of cavities) in late July by splitting the stalks of 40 plants (10 plants per treatment times four replications) in half from the tassel to the ground.

With the exception of Lannate 5G at the rate of 0.25 pounds of active ingredient per acre, all of the materials tested controlled the larvae as well as or better than Furadan 15G (see the table). In particular, the synthetic pyrethroids (Ambush, Ammo, Pounce, and HAG-107) achieved very good control at extremely low rates of active material.

Although the tests were conducted with first-generation corn borers, these insecticides would probably be effective on second-generation borers as well if the applications were properly timed.

Illinois corn producers can look forward to the registration of at least some of these insecticides for European corn borer control on field corn in the near future.

First Generation European Corn Borer Control, Agronomy South Farm, University of Illinois (Champaign County), 1982

Treatment	Rate (pounds of active ingredient per acre)*	Mean number of cavities per stalk†
Ambush 2EC	0.15	0.00 a
Ammo 2.5EC	0.075	0.05 ab
Pounce 3.2EC	0.15	0.10 ab
Larvin 3.2EC	0.60	0.10 ab
Lorsban 4E	0.75	0.18 ab
Lorsban 15G	0.75	0.20 ab
HAG-107 0.3EC	0.016	0.20 ab
HAG-107 0.3EC	0.013	0.20 ab
Orthene 75S	1.00	0.23 ab
Furadan 15G	1.00	0.23 ab
Amaze 20G	1.00	0.23 ab
Lannate 5G	0.50	0.25 ab
Lannate 5G	0.25	0.33 b
Check	--	0.78 c

*Rate for 30-inch row spacing.

†Means based on four replications. Means followed by the same letter are not significantly different at the five percent level (Duncan's Multiple Range Test).

Postemergence Control of Broadleaf Weeds in Soybeans

T.N. Jordan

Many factors must be considered when choosing a postemergence herbicide program for control of broadleaf weeds in soybeans. Part of the choice involves matching the appropriate herbicide with the weed spectrum present in each individual field. Indiscriminately applying broadcast applications of several herbicides on every field can be expensive. Costs can be kept at a minimum, however, by choosing the right herbicide or combinations of herbicides and using them correctly. For example, the cost of controlling morningglory can range from as little as 75 cents per acre to $20.00 per acre, depending on the choice of herbicides and the timing of application.

Early weed control and the establishment of uniform soybean stands are both needed for top yields. Keeping soybeans weed-free for four to six weeks after germination prevents late germinating weeds from becoming competitive and reducing soybean yields. If weeds compete early and reduce the soybean stand, then late germinating weeds will compete even if herbicides are applied.

Timing the herbicide application has been one of the grower's biggest problems in the past. The stage of weed growth has a very profound influence on the efficacy of postemergence herbicides. For consistent results, the weed size maximums on the label must be strictly followed. Because the activity of the herbicide is related to the herbicide rate, the weed species, and its stage of growth, the taller the plants are over the maximum size stated on the label, the more inconsistent the herbicide's performance is.

Other factors to consider in postemergence herbicide applications are the time of day at which the herbicide is applied, the volume of the spray diluent with which the herbicide is applied, and the temperature and relative humidity at the time of application. Still other factors to consider when choosing a herbicide are the management capabilities of the applicator, any restrictions and cautions on the herbicide label, the availability of application equipment, and the cost of the herbicide and the application.

If a soybean field is overtaken by a large population of weeds, then it is not a wise decision to apply a salvage treatment just to keep those weeds from going to seed. There are enough good herbicides available, if applied properly, to control weed seedlings in next year's crop. A salvage treatment is needed only if that treatment will save the present crop and allow harvest of soybeans.

Do not expect too much from postemergence herbicides. As with soil-applied herbicides, even the best postemergence herbicide will not always perform consistently. For optimum control with contact herbicides, the following information should be remembered: (1) small weeds are easier to kill, while the bigger weeds tend to escape; (2) actively growing weeds are more susceptible than weeds under drought stress; (3) herbicides work best when temperatures are warm and relative humidities are high (75 percent or greater); (4) more consistent control is obtained when high-pressure (50 to 60 psi) sprays are used, especially when there is a canopy of vegetation over the weeds; and (5) calibration and application methods also can play a major role. Understanding the variables that affect herbicide performance can aid greatly in achieving good performance with postemergence herbicides.

The growth stage of weeds is an important consideration that cannot be over emphasized. Annual and perennial weeds may need to be treated differently. Annuals should be sprayed when they are small, and complete coverage of the weeds should be obtained. For perennials, translocated herbicides are generally needed to control the underground systems. It is often best to allow several weeks' growth before treating some perennials; waiting allows more movement of the herbicide from the tops into the underground portions of the weed. Thorough coverage of both annual and perennial weeds is generally not as essential for a translocated herbicide as for a contact herbicide.

Environmental and soil conditions that favor good plant growth generally favor good herbicide performance. This is true for both soil-applied and foliar-applied herbicides. Deviations from these "good" conditions will decrease the performance of most herbicides. For example, common milkweed is successfully controlled in soybeans with Roundup (glyphosate) applied through recirculating sprayers or rope-wick applicators when the weed is actively growing with warm temperatures, adequate soil moisture, and moderate to high relative humidity. The same application may be a failure when common milkweed is under drought stress and not actively growing. With postemergence herbicides such as Basagran (bentazon), Blazer (acifluorfen), and Dyanap (dinoseb plus naptalam), good coverage and good growing conditions are needed to obtain best results.

Cracking-Stage Applications

Contact herbicides like Dyanap or Premerge 3 (dinoseb) can be sprayed at the cracking or crook stage of soybean development to control broadleaf weeds. In the Midwest, control of jimsonweed, ragweed, velvetleaf, smartweed, morningglory, and common cocklebur is obtained with these herbicides when growing conditions are good and temperatures are high. Cool temperatures decrease the effectiveness, while abnormally high temperatures and wet soils can increase soybean injury.

Early Postemergence Applications

Weeds that are present when the soybeans are in the second to fifth trifoliolate leaf stage can be controlled with early postemergence treatments of Basagran, Blazer, Vistar (mefluidide), or Dyanap. Weed size is important when using early postemergence herbicides. Some weeds are easier to control than others, and therefore the identification of the species and a consideration of their size are essential.

In addition to controlling annual broadleaf weeds, Basagran can suppress yellow nutsedge and Canada thistle. Two applications, 7 to 10 days apart, may be needed for good control. The use of an oil concentrate with Basagran is recommended when spraying yellow nutsedge. Good pigweed control is obtained by using either Blazer or Dyanap, but Basagran is weak on this weed. Giant ragweed and jimsonweed can be controlled by Basagran, Blazer, and Dyanap when treated at the proper growth stage. If applied early, Basagran can give good control of velvetleaf, but Blazer and Dyanap do not control this weed. Smartweed is controlled better with Blazer or Basagran than with Dyanap. If annual morningglory is of concern, Blazer would be preferred. Cocklebur can be controlled better with Basagran or Dyanap than with any soil-applied material. At the present time, bur cucumber cannot be effectively controlled by postemergence applications.

Directed Spray Applications

Directed herbicide applications offer potential for controlling many weeds in soybeans. This technology, which is limited to crops grown in rows, has been widely used in the southern states but has not been used much in the Soybean Belt of the central states. Directing the spray allows the use of herbicides that cause excessive injury if applied over the top of soybeans. A directed sprayer applies the chemical near the base of the soybeans.

Herbicides used for this type of application include 2,4-DB, Premerge 3, Lorox (linuron) plus 2,4-DB, and paraquat. With these herbicides, it is essential to have the weeds much shorter than the crop so that the weeds can be sprayed without significant contact of the soybean foliage. Directed treatments can be very effective on late germinating weeds or on weeds that have been stunted by soil-applied herbicides. Because of the soybean injury that may occur if the foliage is sprayed, specialized equipment is necessary for this type of application. The equipment needs to allow for precision placement, which requires that the spray nozzles be attached to gauge wheels or skids.

With increased interest in reduced tillage and in narrowing the row widths for soybeans, interest in postemergence treatments is also increasing. Postemergence herbicides are now available for use either as primary control for broadleaf weeds or as a "backup" treatment for control of the broadleaf weeds missed by earlier soil-applied treatments. These new additions to the farmers' arsenal will allow even greater flexibility for modifying cultural practices for soybean production.

There is no substitute for following label directions when applying postemergence herbicides for control of broadleaf weeds in soybeans. Most of the label instructions specify that the herbicide is to be applied when soybeans are in the second to third trifoliolate leaf stage. It is important to know the weed spectrum and to choose the correct herbicide for these weeds. Do not attempt to cut corners by reducing the rates or by applying a single application over an entire field with the expectations of controlling all weeds. While herbicides are expensive, it should be remembered that weeds are also expensive.

Using European Corn Borer Moths to Determine Larval Damage in Corn

W.B. Showers

Monitoring European corn borer, *Ostrinia nubilalis* (Hübner), moth activity can be useful in determining the length and intensity of the moth flight and when to begin field scouting. Nightly flights can be monitored by charting the number of European corn borer moths caught per night in a light trap. The moths may be monitored during the day by disturbing grassy field margins, weedy fence rows, and other areas of dense vegetation where moths aggregate, mate, and feed. These action sites of dense vegetation are necessary "stopping-off" points for female moths before egg deposition in the cornfield.

Locating these action sites and observing moth activitiy can be very helpful. Research using a square meter drop net has shown that the number of female moths in the grass around field edges, in waterways, and between the rows of weedy fields correlates with the number of egg masses deposited on the corn plants (Figure 1). Three females per square meter equal 0.5 egg masses per corn plant. With good weather, this level of infestation could be economic.

Walking through the action site will cause the moths to flutter up. Recent research in Iowa indicates this "flush" method correlates well with the drop-net method ($r^2 = 0.67$) of monitoring adult populations. An average of 61 moths (males and females) in one by ten meters (three feet by 33 feet) of the action site is equivalent to an average of three females per square meter. A minimum of five flush samples should be taken in the grass per eight hectares (20 acres) of cornfield. This adult flushing technique is a useful way to determine whether scouting for egg masses should be started.

The economic injury level is the pest population density at which the value of actual or potential damage equals the cost of preventing the damage (Table 1). The economic threshold is the population density at which control measures should be initiated to prevent the pest density from surpassing the economic injury level.

In order to apply these concepts to the European corn borer, the theory of a treatment "window" must be introduced. Only larvae that have not bored into the plant can be killed. Consequently, there is a specific time period, or "window," during which pesticides must be applied if they are to be effective. Because egg deposition in a given field may last two to four weeks, insecticides must typically be applied before all eggs have been deposited in a field. Otherwise, larvae from eggs deposited early in the egg-laying period will succeed in entering the plant. The decision to treat, therefore, must be based on an estimate of the potential European corn borer population density in the field. The potential population density in a given field may be estimated as follows:

1. Scout the field weekly for borer eggs, including hatched egg masses, or, as previously described, flush the weedy areas around the field for adults.

2. Begin counts of borer egg masses per plant with the first sign of borer eggs in the field. Researchers believe that it is unlikely that eggs can be detected before five percent of the eggs are in the field. This assumption becomes an integral part of calculating the potential population density.

3. Calculate the potential population density (PPD) per plant by:

$$PPD = \frac{SV \times 23 \times EM}{PO}$$

Where: EM = the number of egg masses per plant

23 = the average number of eggs per mass

SV = the average proportion of individuals surviving through the damaging stage. Based on studies from Iowa and Kansas, a value of 0.2 is recommended.

PO = the proportion of the total egg compliment deposited before detection in the field, which is 0.05

4. The field should be sampled and the potential population density calculated again eight days later. Assume at this time that 50 percent of the egg compliment has been laid (based on an assumption of a three-week egg-laying period). Thus, PO = 0.50.

Although the economic threshold is usually less than the economic injury level, in this case they are the same thing since we are making the control decision before all of the borer population is present in the field (so the insect is destroyed before it reaches the damaging stage). The economic threshold thus may be estimated as follows:

1. Determine the cost of control (dollars per acre). This cost includes the cost of insecticides and the cost of application by ground or air.

2. Estimate the market value of the crop (dollars per bushel of corn) at the intended time of sale and the crop yield (bushels per acre) at harvest.

3. The economic threshold (ET) is then calculated by:

$$ET = \frac{CC \div MV}{(DL \div 100) \times EY}$$

where: CC = control costs (dollars per acre)

MV = market value (dollars per bushel)

DL = percent damage loss (per borer per plant) at the time of infestation (Table 1, column 2)

EY = estimated yield (bushels per acre)

At this point, the treatment decision can be made by comparing the potential population density (PPD) to the economic threshold (ET). If PPD is greater than or equal to ET, then treatment is warranted. For example: Assume that on the second sampling date (eight days after initial borer detection and during pollen shed) you counted 15 egg masses per 100 plants sampled:

$$\text{PPD} = \frac{\text{SV x 23 x EM}}{\text{PO}} = \frac{0.2 \text{ x } 23 \text{ x } 0.15}{0.5} = 1.38 \text{ larva per plant}$$

After talking with the aerial applicator, you determine that control costs will be \$16.00 per acre for a single insecticide application. You estimate that the crop will yield 140 bushels per acre and that you will receive \$3.40 per bushel at sale (Table 1).

$$\text{ET} = \frac{\text{CC} \div \text{MV}}{(\text{DL} \div 100) \text{ x EY}} = \frac{\$16.00 \div \$3.40}{(4.4 \div 100) \text{ x } 140 \text{ bushels}} = 0.76 \text{ larvae per plant}$$

In this example, PPD (1.38 larvae per plant) is greater than ET (0.76 larva per plant) and treatment is economically justified. Using this procedure in 1981 during a pilot European corn borer management program, the proper treatment decision (based on a single insecticide application) was reached in seven of eight Kansas fields. Potential users of this procedure must remember that virtually any factor that affects one of the variables in the equations could change the decision. Incorrect estimates of a variable could cause you to reach an economically unjustified treatment decision. Assumptions concerning the length of the egg-laying period (which influences PO), the proportion of larvae surviving (SV), and the damage loss relationships (DL) are the weakest portions of the procedure. Research currently underway in a number of states should improve the procedure. Users may wish to contact the appropriate research or Extension representatives to obtain any recent modifications before using the method.

Showers, W.B.; Witkowski, J.F.; Mason, C.E.; Poston, F.L.; Welch, S.M.; Keaster, A.J.; Guthrie, W.D.; Chiang, H.C. Management of the European corn borer. Ames, Iowa: Iowa State University, North Central Regional Publication 22, in press, 1983.

Table 1. Corn Loss Caused by European Corn Borers and Calculated Economic Injury Level for Various Corn Growth Stages (Adapted from R.E. Lynch and F.L. Poston, "Management of the European Corn Borer," in Press)

		Calculated economic injury level[a]	
Plant stage	Percent loss (borers per plant)	One application	Two applications
Early whorl	5.5	0.61	1.22
Late whorl	4.4	0.76	1.53
Pre-tassel	6.6	0.51	1.02
Pollen shedding	4.4	0.76	1.53
Kernels initiated	3.0	1.12	2.24

[a]Control costs were \$16.00 per acre for one application and \$32.00 per acre for two applications. Market value was \$3.40 per bushel, and the estimated yield was 140 bushels per acre.

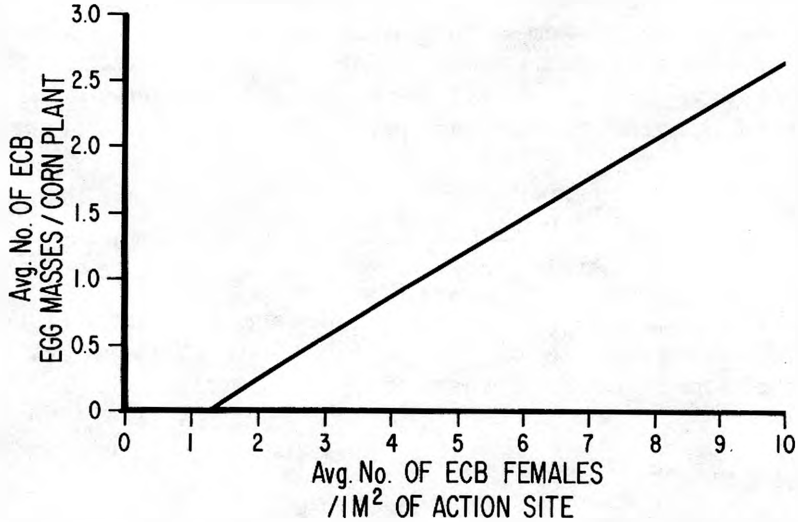


Figure 1. Predicted number of European corn borer egg masses per corn plant, based on number of female European corn borer moths per square meter of dense grass.

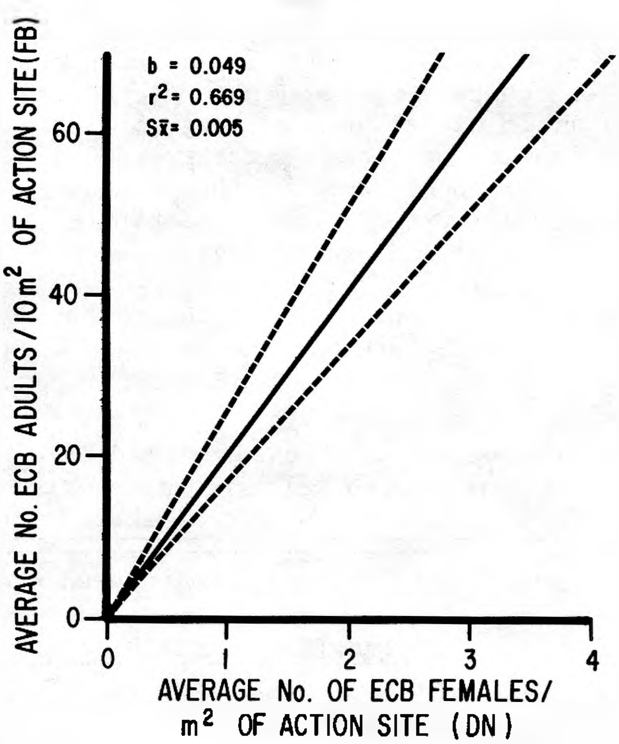


Figure 2. Correlation between the average number of European corn borer moths flushed in 10 square meters and the average number of females in one square meter of dense grass (Sappington and Showers, unpublished).

Low Volume, Uniform Droplet, CDA, and Electrostatic Sprayers—What's Going On?

E.J. Matthews

Development of better pesticide application equipment has been slow, agonizingly slow. In fact, Graham Matthews, in a paper presented at the Ninth International Congress of Agricultural Engineering, stated that the basic design of spraying machinery has changed little since the turn of the century. I consider this fact to be a truthful and serious indictment of our lack of development of markedly better application equipment. We are still mostly just "dumping it on" with very low effective utilization of the active pesticide. Given the typical range of droplet sizes of most hydraulic spray nozzles, most large droplets hit only the top of the target, and many of the smaller droplets of volatile carrier liquids just dry up and drift away.

To improve spraying efficiency, we need to be able to apply less volatile formulations in an appropriate droplet size range so that the droplets collect properly on the biological target. For example, droplets in the 30- to 100-micron range are readily carried by air currents within the crop canopy and are intercepted by the foliage. Droplet movement within the crop canopy generally increases deposition, especially on the lower side of plant leaves.

Improved atomizers will give uniform droplet sizes and largely eliminate the very fine droplets that are most prone to drift into undesired locations. However, gravity and the inertia imparted to spray droplets by atomizers may not adequately transport the small droplets involved in ultra-low volume spraying. At present, either a turbulent air blast or electrostatic charging is usually used for supplementary transport and control of small spray droplets. A turbulent air blast works quite well with orchard trees, vineyards, and some field crops, but it generally does not work well in row crops, even when controlled droplet atomizers are used.

Electrostatic charging of pesticide particles by a high voltage charge opposite in polarity from the charge on the biological target is an effective means of transporting small particles to the target. Dr. Coffee states that the "Electrodyn" electrostatic sprayer charges 50 micron droplets with an electric charge that has a force on the droplets from two to ten times the force of gravity. This charge is with oil-based sprays with application rates of 0.05 to 0.10 gallon per acre.

Controlled Droplet Atomizers

One of the most widely used application units for producing a narrower droplet spectrum is the spinning disc. Detailed studies on the formation of droplets in a spinning disc have been carried out by several researchers since 1949. Depending on the operating parameters, spinning discs initially form single droplets, ligaments, or sheets as well as combinations of each of these. In 1970, Bals designed a toothed disc to provide issuing points for droplets and ligaments to leave the disc. Subsequent designs added grooves to feed the teeth and improved the unit so that larger volumes could be applied without sheet formation. These discs are usually powered by small, direct-current, electric motors. Speed is controlled by voltage control or other variable speed drives.

Frost tested two commercial spinning discs. The "Micron Herbi" is a 3.1-inch-diameter disc with an upturned lip and serrated edge. This unit operates by direct drop formation, has low output, and is designed for hand-held applications. Frost found the "Herbi" output to be a maximum of 0.024 gallon per minute. With higher rates, and more ligament formation, the droplet size range widens. The application capacity of the "Herbi" is thus lower than is probably desirable for a field machine.

Frost's tests of the "Micron Battleship" atomizer (a conical, 3.9-inch-diameter, toothed disc) showed that it gave more uniform droplet sizes at 2,000 rpm and 0.132 gallon per minute than at 3,000 rpm and 0.26 gallon per minute. Ligament production was irregular at the higher speed, and 0.132 gallon per minute and 51.2-inch spacing gave 3.3 gallons per acre at 4.5 miles per hour. No drops smaller than 50 micron were observed in these tests.

The "Beecomist" rotary atomizer is being developed by Beeco Products Company and promoted by Webb Wright Corporation. It is a spinning cage unit with variable-speed hydraulic or electric motor drive. The droplet size range is changed by varying drive speed and changing the spinning cages to ones with larger or smaller openings. This unit is made in several sizes ranging from hand-carried units to large ground sprayers and aircraft units. The unit appears to give a narrow range of droplet sizes.

Electrostatic Sprayers

Prototypes of production electrostatic sprayers based on Dr. Edward Law's patents were field tested from 1978 to 1980 by the FMC Corporation. These machines have been used principally for insecticide applications on many different crops and have given generally favorable results. The design typically uses a compressed-air atomizer nozzle where the air blast drives the spray particles through an electrostatic induction charging ring that operates at about 4,000 volts D.C. The force of the air drives the charged spray particles down into the plant canopy where the particles slow down; particle movement is then controlled by the charge on the particles. Concentrated, low-volume, water-based pesticide mixes are typically used with this unit. These nozzles require about 1.3 horsepower to supply air to each nozzle.

Electrostatic spraying has much potential, especially if a simpler, low-cost, effective unit is developed. Imperial Chemical in the United Kingdom is developing an "Electrodyn" electrostatic atomizer head with no moving parts. The charging voltage produces ligaments and very small droplets. Spray materials are supplied in sealed containers that are inserted into the charging unit for application. Hand-held units are now being sold overseas, and tractor-mounted units are being extensively tested in the United States preparatory to the proposed 1984 marketing goal. These units use only oil-based sprays supplied in sealed, premixed containers by the manufacturer, National Institute of Agricultural Engineering, and also by ICI in the United Kingdom.

Researchers at Rothampsted (United Kingdom) have developed a spinning-disc, electrostatic atomizer unit using corona charging (the APE80). This unit permits the use of oil-based liquids that do not charge well in some electrostatic units.

The Micron "Micromax" and similar spinning, toothed-disc, ultra-low-volume atomizers have been marketed in the United States since 1980. These units can give a good droplet spectrum if properly operated. Changing spinner speed or flow rate will change the droplet sizes obtained. The volume handled is similar to the discharge volume of a "Spraying Systems" 8002 flat-fan hydraulic nozzle. Bode and Butler have reported that the coefficient of variation for "Micromax" units was reduced to 4 percent with 40-inch spacing between units. This report also found that drift from this spinner atomizer was similar to that of the 8002 hydraulic nozzles at wind speeds up to 2.7 miles per hour, but that drift from the spinners increased dramatically above drift from the 8002 nozzles at higher wind speeds.

Field Tests

Engineers at the University of Arkansas obtained prototype sprayer components in 1980 from FMC and mounted the equipment on a tractor and used the unit for directed postemergence herbicide applications of dinitroaniline on soybeans and for overtop herbicide applications of bentazon. Applications were made at normal and half rates using 2.3 gallons per acre total mix rather than the typical 25 gallons per acre used with hydraulic nozzles. Test results are shown in Table 1 and are favorable in terms of good weed control even when only one-half of the normal pesticide rate was used. The large air compressor and complex plumbing required with this machine did present some problems, although function was good.

Insecticide application tests were made with the electrostatic sprayer on field plots of cotton in 1980 and 1981 at the University of Arkansas's Southeast Branch Experiment Station in cooperation with entomology researchers. Results with the low-volume electrostatic sprays were quite favorable. In a 1981 test of larvicides, cypermethrin at 0.043 pound active ingredient per acre gave 95 percent bollworm control and 100 percent budworm control when the spray was electrostatically charged, and 73 percent and 90 percent, respectively, when uncharged. Electrostatic spray was the best of 22 treatments in this test. Control typically was reduced 10 percent to 25 percent when electrostatic charging was not used. Visual observation of spray applications indicated that there was a much greater spray particle deposition on the plants when electrostatic charging was used.

Researchers from Rothampsted tested two hand-held electrostatic, spinning-disc atomizer prototypes in July, 1981, at the Southeast Branch Experiment Station as well. These units operate with charging voltages up to 25k. Good results were obtained with these small units, which were powered from a 12-volt battery pack. It is interesting to note that in one test more than 75 percent of the spray material was deposited on the bottom of cotton leaves. This unit is now being marketed in the United Kingdom.

Conclusions and Projections

It is my opinion that we are in the initial stages of a revolution in pesticide application with ground-operated equipment. We already have some of the hardware in commercial form that will *control droplet size so that the droplets will collect properly on the biological target.* Uniform, small droplets with electrostatic charging give good coverage of the biological target. The standard application rate for the "Electrodyn" field unit prototype is 0.10 gallon per acre. Some herbicide rates may be cut in half without reducing effective control. Rates can no doubt be reduced further as equipment is improved.

There are now two or more hand-held, electrostatic spinner atomizer units commercially available overseas. Several field-size prototypes are now being tested in the United States and abroad. I predict that there will be three or more of these field-type electrostatic sprayers on the market by 1984. It looks like we are finally reaching the point in sprayer development and marketing where we will be able to get the pesticide on the pests and not waste the great majority of the spray material.

Table 1. Soybean Weed Control Equipment Test, 1980[a]

Treatment	Visual weed control ratings (8-2-80)	
	Percent plant injury	Percent weed control
1. Conventional post-directed dinitro	0	77
2. Tri-nozzle overtop bentazon	0	77
3. Experimental air shield post-directed dinitro	2	82
4. Untreated check	0	0
5. Electrostatic post-directed dinitro	14	79
6. Electrostatic over-top bentazon	0	88
7. Electrostatic over-top bentazon, 1/2 rate	1	88
8. Tri-nozzle overtop bentazon, 1/2 rate	0	38
9. Electrostatic post-directed dinitro, 1/2 rate	5	79
10. Tri-nozzle overtop bentazon	0	73

[a]Tests were conducted at the Delta Branch Station of the Arkansas Agricultural Experiment Station. The soil is a clay loam. The test field was treated with trifluralin, preplant incorporated. Applications were made on 6-10-80 and 6-24-80. Weed infestations were primarily cocklebur with some prickly sida, morningglory, and jimsonweed. Two gallons per acre total mix was applied.

New Postemergence Herbicide Treatments for Corn

F.G. Burroughs

Over the past five or six years, the Corn Belt farmer has been accepting the use of postemergence herbicide applications on a broader scale. The introduction of a limited number of fairly effective materials during this period and the trend toward reduced tillage practices have encouraged this increased acceptance. Although most of the recent advances in postemergence weed control have benefited the soybean grower, many compounds are now in the developmental stage that may someday provide the corn grower with outstanding grass and broadleaf weed control.

The most promising of the postemergence compounds under development for grass weed control in corn is Dowco 356® (see Table 1). In combination with atrazine or cyanazine, this compound provides outstanding control of annual grasses and broadleaf weeds up to four to six inches in height. This compound is in its third consecutive year of study at the University of Illinois and will be available on a very limited basis under an Experimental Use Permit during the 1983 growing season.

Three new postemergence compounds for the control of broadleaf weeds were also examined at the University of Illinois this year. Several treatments that are currently registered for use on broadleaf weeds in corn were also examined for comparison. Velvetleaf (*Abutilon theophrasti*) is the number-one broadleaf weed in the Corn Belt and proved most troublesome for the new treatments (see Table 2). Several currently available treatments such as 2,4-D and dicamba (Banvel®) readily controlled this weed. The other weeds included in this test were jimsonweed (*Datura stramonium*), Pennsylvania smartweed (*Polygonum pensylvanicum*), and common lambsquarters (*Chenopodium album*). These three proved somewhat less difficult for the new treatments to control than velvetleaf, but none were sufficiently controlled by the new treatments.

Although injury to the corn was not a problem in the tests, it should be noted that the potential for injury does exist with the currently registered treatments of 2,4-D or dicamba, especially if they are applied when the corn is very rapidly growing or between the tassel to dough stages of ear development. The potential for crop injury from the new compounds has not been fully assessed; several more years of examination are required to reliably predict whether injury will occur.

The expansion of the chemical arsenal for postemergence weed control is certainly a good sign for the corn producer. It means that several options will become open with regard to tillage practices and crop rotations that are now limited because of lack of reliable weed control.

Table 1. Percent Giant Foxtail Control with Various Rates of Dowco 356 and Atrazine/Cyanazine

Treatment[a]	Rate (pounds per acre)	Percent giant foxtail control[b]
Dowco 356 + atrazine + cyanazine	0.75 + 0.75 + 0.75	93
Dowco 356 + atrazine	1.0 + 1.5	91
Dowco 356 + atrazine + cyanazine	0.25 + 0.75 + 0.75	90
Dowco 356 + atrazine	0.25 + 1.5	86
Atrazine	1.5	75

[a]Treatments applied to giant foxtail four to six inches tall. All treatments contained Sun 11E® crop oil at one quart per acre, except atrazine alone, which contained Amoco crop oil concentrate at one quart per acre.
[b]Seven days after treatment.

Table 2. Percent Broadleaf Weed Control with Various Postemergence Treatments

Treatment[a]	Rate (pounds per acre)	Percent control[b]			
		Velvetleaf	Jimsonweed	Smartweed	Lambsquarters
Banvel 4L	0.25	100	100	100	100
Banvel II	0.25	90	100	90	90
2,4-D amine	0.25	90	90	80	80
2,4-D amine	0.40	100	100	100	100
Bromoxynil	0.25	90	95	80	85
Bromoxynil + atrazine	0.25 + 0.50	100	100	100	100
Benazolin	0.25	85	100	90	80
Benazolin	0.50	100	100	100	100
Benazolin + atrazine	0.30 + 0.30	100	100	100	100
Vel 4359T	0.25	75	85	95	70
HP 783	0.50	0	0	0	0
HP 783	1.0	25	40	60	30
HP 783	1.5	75	60	60	40
PPG 1259	0.05	0	0	0	0
PPG 1259	0.20	100	100	100	100
Laddok	0.80	100	100	100	100
Laddok	1.0	100	100	100	100

[a]Treatments applied to broadleaf weeds two to four inches tall.
[b]Four weeks after treatment.

Monitoring for Black Cutworms and Corn Rootworms

S.P. Briggs and J.T. Shaw

Black Cutworms

During the past three years entomologists from the University of Illinois and the Illinois Natural History Survey have coordinated the black cutworm pheromone trap project. With help from the county Extension advisers, the project has grown from 110 local cooperators in 75 counties in 1980 to 231 cooperators in 87 counties in 1982. The project represents the largest pheromone trapping program for black cutworms in the United States.

Since the majority of black cutworms migrate into Illinois each year, it is possible to distinguish the dates that the moths arrive in the different regions of Illinois by using the pheromone traps. Cooperators check their traps daily and record the number of moths captured. Each week, postcards with the daily catches are sent to the Illinois Natural History Survey, where the numbers are entered onto the computer for tabulation and data storage.

Researchers from the Illinois Natural History Survey have developed a computer program to predict the initial damage date for black cutworms based on the pheromone trap catches and the accumulated and projected weather. This computer program should be available to Extension advisers who have computers in the near future. Presently, the damage dates are published weekly in the *Insect, Weed, and Plant Disease Survey Bulletin.*

1982 Findings

In 1982 the spring moth flight occurred earlier and with more intensity than the flights of 1980 and 1981. The damage dates projected by the computer were also a few days earlier in 1982 than in 1980 and 1981 (Table 1). However, favorable early spring weather allowed most farmers to do their spring tillage operations and to plant relatively early. Few black cutworm problems were reported in 1982. Entomologists have long said that eliminating spring weed growth and planting early will reduce the potential for black cutworm damage.

Where damage did occur, our predicted dates correlated very closely with the actual day of damage. Because the dates proved fairly accurate, they allowed farmers and others interested to scout their fields for cutworms and to better time their field visits.

It is necessary to point out that the prediction does not state that there will be cutworm problems nor does it project the intensity of any observed problems. It does, however, signal a time when cutworm activity will take place if cutworms are present.

Plans for 1983

What's ahead for 1983? Tentatively, we plan on operating the pheromone trapping program again in 1983. The number of traps that are available will depend on our funding.

It is hoped that area advisers in pest management will begin to coordinate a trapping program in their region. Local coordination is now possible with the addition of microcomputers to each region.

As we accumulate more data each year, the confidence in and accuracy of the projected damage dates will increase. Advisers, farmers, and others involved in agriculture have become comfortable with the prediction of the black cutworm damage dates. This program has been and will continue to be an important tool in a total management program for black cutworms.

Corn Rootworms

With the appearance of the western corn rootworm in Illinois cornfields in 1964, a need developed for an easy and accurate method of measuring the populations of northern and western corn rootworm beetles in a cornfield so that growers could determine which fields needed soil insecticides.

These beetles deposit eggs in the soil in cornfields in late summer. The eggs diapause, overwinter, and hatch in June. The larvae feed on corn roots and complete their development in July. The adults emerge and oviposit, and the annual cycle is repeated. Continuous corn provides the most favorable habitat for survival and increase of these corn rootworms. When crops are rotated, the rootworm larvae perish. Crop rotation is a good pest management program for western and northern corn rootworms.

Many farmers grow continuous corn, and a majority use soil insecticides to protect against attack from rootworms and some other soil pests. In surveys conducted in Illinois over the past 10 years, the number of corn acres needing a soil insecticide to protect against rootworms varied from 12 percent to 35 percent, yet Illinois growers annually treated 50 to 60 percent of the corn acreage with soil insecticides, mainly as protection against the corn rootworms.

There are two basic sampling categories that have been used to estimate the potential for corn rootworm larvae damage the following year: visual beetle counts and mechanical trapping. Visual beetle counts involve (1) counting the number of beetles on the entire plant of a specified number of corn plants, or (2) counting the number of beetles in the ear zone of a specified number of corn plants, or (3) collecting and counting all the beetles on a specified number of ear tips, or (4) counting as many beetles as are visible during a specified timed interval. Mechanical trapping involves (1) pheromone sex traps, (2) color attractancy traps, or (3) food attractancy traps.

The currently recommended procedure calls for growers or professional pest scouts to make three visual adult beetle counts during the time when high egg oviposition is occurring between August 1 and August 31. These counts are to be made at 7- to 10-day intervals in fields that are to be planted to corn the following year. Because beetles seek resting places at various times each day and do not move actively on windy or cool days, adult beetle counts are probably not reliable, especially given the human error inherent in the visual count technique. Thus, the visual count methods have not been readily accepted by growers. It is for these reasons that Illinois is devoting more time and research to the mechanical-trapping sampling methods.

A trap (monitoring tool) is needed that can be put into place and retrieved later and that will remove human error and the daily effects of climate on the beetles. Numerous corn rootworm traps have been devised and tested by entomologists in the Corn Belt states during the past five years, but none has proved workable. The traps are large, either in size or weight, are usually painted yellow to attract the adults, and are coated with a tacky substance to catch the beetles. The Illinois approach is different in that the trap being developed is small and cheap and employs no sticky material.

The concept used in the Illinois trap design is based on two facts; namely, (1) rootworm beetles search for places to hide and rest on the corn plant (usually behind the leaf sheaves) sometime each day, and (2) cucurbitacins are feeding stimulants/arrestants that cause a beetle to feed (the stimulant) and to remain at that location (the arrestant) when in contact with the compounds. The arrestant terminates all other activity, and the insect remains in one spot until all the cucurbitacins have been consumed. Thus, the Illinois trap was designed to attract beetles that are seeking a resting place and to keep the beetles inside the trap with the cucurbitacins long enough for a very small amount of carbaryl insecticide to kill them.

The rootworm monitoring trap is made from a 16-dram plastic vial with a one- by three-inch plastic sheet insert coated with a mixture of carbaryl insecticide and dried, powdered squash high in cucurbitacins.

In 1981, traps containing 7 to 14 holes, 3/16-inch in diameter, were evaluated, and there was a direct correlation between the number of holes and the number of adult beetles captured. Traps containing 10 holes of the same diameter were selected for the 1982 testing program.

Traps containing inserts treated with cucurbitacins and carbaryl trapped 2.46 beetles per trap per day in 1981 and 1.59 beetles per trap per day in 1982. Traps with inserts treated only with carbaryl trapped 0.22 and 0.065 beetles per trap per day in 1981 and 1982, respectively. Numbers of dead beetles were found just outside the traps containing only carbaryl, which indicates that the beetles entered the trap, got a lethal dosage of insecticide, but left the trap before dying. Thus, cucurbitacins definitely keep the beetles in the trap long enough for the insecticide to kill them while they are still in the trap, and this holding power is a crucial factor in the efficiency of the trap. Traps were placed on the corn plant with a wire "twist-em" at ear zone height near the base of the primary ear.

Traps (80 traps per field) were counted in 1981 on the following schedule: (1) 20 traps every day, (2) 20 traps every second day, (3) 20 traps every fourth day, and (4) 20 traps every eighth day beginning on July 21 and ending on August 30, 1981. The 1982 trap schedule (60 traps per field) was: (1) 20 traps every fourth day, (2) 20 traps every eighth day, and (3) 20 traps every twelfth day beginning on July 30 and ending on September 4, 1982. Visual beetle counts were made in 1981 and in 1982 to compare with the numbers in the cucurbitacin beetle trap. Egg samples were taken in all fields in the fall of 1981 and 1982. Root ratings were made in July 1982 for the 1981 study fields and will be made in July 1983 for the 1982 study fields.

Initial data show that the trap is extremely effective in capturing rootworm beetles. There was a high degree of correlation between the average number of beetles caught on the 1-, 2-, 4-, and 8-day trapping periods in 1981 (Table 2), as well as between the 4-, 8-, and 12-day trapping periods in 1982 (Table 3).

In summation, sufficient laboratory and field evaluations have been done to show that this inexpensive type of trap could be extremely effective in monitoring populations of adult rootworms in Illinois cornfields in the near future.

Table 1. Summary Table for 1982 Black Cutworm Pheromone Trapping Project[a]

Region	Average daily catch for week of 3/14	3/21	3/28	4/4	4/11	4/18	4/25	5/2	5/9	5/16	5/23	5/30
Northwest	-	0	1.4	0	0.8	0.7	0.8	1.2	1.0	1.5	0.8	0.7
Northeast	-	-	-	-	1.0	0.9	0.7	0.8	0.7	1.3	0.9	0.9
West	0	0	1.4	0.1	2.1	1.3	1.8	1.4	0.6	0.9	0.6	0.5
Central	-	0.3	3.8	0	2.2	1.1	1.3	1.1	0.4	0.9	0.6	1.3
East	0.6	0.1	2.3	0	1.6	1.2	1.1	1.2	1.1	1.2	0.6	0.5
West southwest	-	0.3	2.1	0.2	1.8	0.9	1.7	0.7	0.5	0.4	0.4	0.5
East southeast	0	0.3	1.6	0.2	1.9	1.2	1.4	1.0	0.7	0.4	0.3	0.4
Southwest	1.7	0.8	1.1	0.4	1.8	1.2	1.7	0.7	0.7	0.6	0.5	0.2
Southeast	1.0	0.7	1.3	0.5	1.9	0.8	1.5	0.6	0.5	0.3	0.3	0.6

[a]The total number of cooperators was 231; the total number of counties involved was 85; and the total number of moths caught was 10,284.

Table 2. Measuring Corn Rootworm Beetle Populations in Cornfields with Traps Baited with Cucurbitacins and by Visual Counts of Adult Beetles in 1981 and Damage to Corn Roots in 1982

	Cucurbitacins + Sevin: Average no. rootworm beetle/trap/day, 1981				
Field No.	1 day	2 days	4 days	8 days	Root ratings of rootworm larval damage,[a] 1982
1	0.76	0.65	0.53	0.53	2.0
2	10.3	10.8	11.7	12.6	3.5
3	7.0	7.5	9.5	8.8	4.3

[a]Root rating: 1 = no damage; 6 = roots completely destroyed. Economic losses in yield occur at root ratings of three and above.

Table 3. Measuring Corn Rootworm Beetle Populations in Cornfields with Traps Baited with Cucurbitacins and by Visual Counts of Adult Beetles in 1982 and Damage to Corn Roots in 1983

	Cucurbitacins + Sevin: Average no. rootworm beetle/trap/day, 1982			
Field No.	4 days	8 days	12 days	Root ratings of rootworm larval damage,[a] 1983
1	3.24	3.24	2.67	--
2	5.58	6.25	6.09	--
3	1.67	1.12	1.28	--
4	7.53	8.86	8.72	--
5	10.65	10.60	9.97	--

[a]Root rating: 1 = no damage; 6 = roots completely destroyed. Economic losses in yield occur at root ratings of three and above.

Vegetable Oils as Pesticide Carriers

B.J. Butler and L.E. Bode

Since cottonseed and soybean oils have been used successfully as carriers for aerial application of synthetic pyrethroids to cotton, a great deal of interest has been expressed in expanding their use. Use of vegetable oils as carriers is only economically feasible when low gallonages are used. Fortunately, low-volume, controlled-droplet applicators (CDA), with and without electrostatic charging of the spray droplets, are coming on the market that can be used for low-gallonage ground applications.

Low volume and ultra-low volume applications would allow both aerial and ground operators to spray many more acres per tankful, spend less time filling tanks, and spray more acres per day. If soybean or cottonseed oil is used as a carrier, the spray droplets should be relatively nonevaporative and should drift less than water droplets of the same size. They also should deposit better than partially evaporated water droplets.

The techniques for applying 10 gallons per acre or more using hydraulic nozzles have been developed over many years. Developing equipment and techniques to apply pesticides in soybean oil carriers at two gallons per acre or less is difficult, but the advantages make such development desirable and probably inevitable. The changed physical properties of the pesticide-soybean oil spray mixtures need to be carefully considered and accounted for in the design and use of the spraying system.

The viscosity of the oil-based spray mixture will be much higher than that of water, especially at the lower air temperatures frequently encountered in the spring in the Midwest. When hydraulic nozzles are used, this higher viscosity can affect nozzle output and will definitely affect nozzle patterns.

If spinning-cup or spinning-disk controlled-droplet applicators are used, spray patterns also will be affected. Droplet sizes will be affected with all types of atomizers.

Vegetable oils can also be used in place of petroleum-based crop oils that are added to water carriers along with the pesticide to improve efficacy.

As part of a research grant from the American Soybean Association, we are measuring the physical properties of both once-refined and fully refined soybean oil over a temperature range of 40° F. to 100° F. We are duplicating the tests using the oils in various dilutions of selected herbicides, fungicides, and insecticides. We then will determine the effect that these various mixtures have on flow rates and distribution patterns. We know, for instance, that higher viscosity mixtures cause flat-fan nozzles to produce a spray pattern with heavier edges than normal and with a narrower spray angle. If flat-fan nozzles are used to spray vegetable oils in cool weather, nozzle height will need to be increased to obtain approximately 100 percent overlap rather than the 50 percent normally recommended for water-based sprays.

We are going to determine the droplet sizes produced when vegetable oil carriers are used with both CDA applicators and hydraulic nozzles. We will then make comparative spray drift tests, using what seem to be the better spray systems, to quantify the drift control benefits and any improvements in target deposition.

Guidelines and Policy for Pesticide Waste Management in Illinois

A.G. Taylor

Pesticide waste management is becoming an integral part of the custom applicator's daily operation. This fact is attributable to the promulgation of regulations calling for the discreet handling of all commercial waste products and to the positive response of spray operators to the need for maintaining both a habitable and safe working environment.

Hazardous Waste Regulations

The Resource Conservation and Recovery Act (RCRA) passed by Congress in 1976 is the most stringent of the solid waste regulations. It sets forth criteria to identify, handle, and determine the fate of hazardous wastes. State regulations that parallel RCRA have been adopted by the Illinois Pollution Control Board and are enforced by the Illinois Environmental Protection Agency (IEPA). The state and federal hazardous waste programs will ultimately be merged into one system administered by IEPA.

A commercial enterprise becomes involved with these regulations when it generates wastes containing one or more of the chemicals identified as hazardous by the state or federal criteria. Most pesticides used in Illinois agricultural production are not categorized as hazardous wastes; however, a few that may be quite important to a particular custom operation, such as 2,4-D and methyl parathion, do meet the requirements.

2,4-D is classified as a toxic waste chemical, and methyl parathion is classified as acutely hazardous. An industry that produces 2,200 pounds per month of a toxic waste or 2.2 pounds per month of an acutely hazardous waste must register with the U.S. Environmental Protection Agency's regional administrator as a hazardous waste generator.

Generators who store hazardous wastes longer than 90 days or who treat their wastes are subject to additional regulatory requirements. Treatment and storage facilities include clean-up storage tanks, evaporation basins, surface impoundments, and land disposal sites. Emergency contingency plans and closure plans must be prepared for these facilities. The closure plan must include an estimate of the maximum inventory of wastes in storage or treatment at any given time during the life of the facility and the procedures required to decontaminate the facility and equipment at the time of closure.

Groundwater monitoring systems are required for surface impoundments (pits, ponds, and lagoons), below-ground tanks, and landfills. In some cases, post-closure monitoring may also be required.

All owners and operators of hazardous waste treatment, storage, and disposal facilities must demonstrate financial responsibility for bodily injury and property damage to third parties caused by sudden accidental occurrences. The minimum amount of this coverage is \$1 million per occurrence and \$2 million annual aggregate. Owners or operators of landfills, surface impoundments, or land treatment facilities must also demonstrate financial responsibility for nonsudden accidental occurrences in the amount of $3 million per occurrence or $6 million annual aggregate. In addition to these obligations, the owner and operator must establish financial assurance for closure of the facility through a closure trust fund, security bond, closure letter of credit, or a combination of these mechanisms.

Nonhazardous Waste Categories

Pesticide containers that have been triple-rinsed, empty paper bags, and cardboard containers are classed as general refuse and can be disposed of in a licensed sanitary landfill. Unrinsed containers, solutions, rinsates, unused materials, and other residues that contain nonhazardous pesticide chemicals are classed as special wastes when being discarded or when they are intended to be discarded. These wastes must be taken to a landfill or treatment facility permitted to accept special materials. It is important to note that when a nonhazardous waste as described here is mixed with a hazardous waste, the entire volume of the mixture is considered hazardous and must be handled accordingly.

Restricted Disposal Practices

The alternative of landfilling wastes is becoming more restricted. The "city dump," once a convenient avenue of disposal for almost any waste product, no longer legally exists. Operators of licensed sanitary landfills are limited to accepting general refuse and are quite particular about receiving only triple-rinsed containers and uncontaminated wastes.

Disposal of special and hazardous pesticide wastes is allowed only in a small number of Illinois landfills. Currently, six hazardous waste sites and approximately forty special waste sites have state operating permits, but not all of them will accept pesticide wastes. Most are located in the northern third of Illinois and are therefore located too far for most waste generators in the central and southern part of the state. Disposal fees as high as $400 to $500 per 55 gallon drum of waste may also be prohibitive for many small businesses.

It has been a common practice to discharge tank rinsings and other pesticide-laden washwaters directly into stormwater drainage ditches or sanitary sewers. This practice is prohibited by both federal and state regulations without first obtaining a National Pollutant Discharge Elimination System (NPDES) permit from the IEPA Division of Water Pollution Control and providing some form of treatment to decontaminate the waste.

A number of custom operators burn their used containers and paper wastes to avoid the inconveniences and costs of landfilling. Provisions in the state's air pollution regulations restrict the open burning of all commercial wastes.

With a farmer's permission, a commercial applicator can burn containers used on the farmer's field at the site where the pesticide was applied. A commercial applicator cannot burn pesticide containers in the open, however, at his place of business. To burn at a commercial site, an incinerator is needed. The incinerator design must be approved prior to construction by the IEPA Division of Air Pollution Control. After installation, a permit must be obtained from the Agency to commence operations.

Even though Illinois law allows certain types of open burning, municipal and county ordinances may not. It is advisable to check with local officials before burning.

Recommended Management Practices

A reference document entitled "A Guide to Minimizing Problems of Pesticide Waste Management" was recently developed and published by the Joint Illinois EPA, Illinois Department of Agriculture, and Industry Task Force on Pesticide Waste Management. The document provides custom spray operators with a variety of recommended practices and procedures to prevent pesticide-waste-related problems. Recommendations, described in more detail in the guideline manual, are outlined in the following paragraphs.

Management strategies for handling pesticide wastes include volume reduction, resource recovery, disposal, and treatment. Some of the techniques involved are quite simple and, when implemented, cause little expense to the custom operator. Others involving disposal or treatment can be complex and costly and require competent management capabilities.

Minimizing the quantity of waste produced is most advantageous. Accurately measuring treatment areas and properly calibrating equipment will reduce amounts of excess solution. Scheduling applicator units successively on the same crop will decrease the number of tank rinsings and allow leftover solutions to be consumed.

Field equipment spraying crop-protection chemicals should carry a supply of fresh water at all times. A 50- to 100-gallon drum mounted on the carrier frame and plumbed into the suction side of the pump (Figures 1 and 2) provides a ready source of water to flush the spray system in the field. Nurse trucks supplied with the flush tank system can pump rinsewater into the applicator spray tank. When chemicals are applied at the low to middle end of the required rate, the rinsate can be applied to the field at a reduced rate without encountering problems of crop damage or label violations.

Bulk handling is an alternative to the accumulation of a large number of empty chemical containers. Fifty-five-gallon drums, 250-gallon mini-bulk carriers, and larger permanent storage tanks are utilized in bulk systems. Conversion to bulk handling should be considered if the volume of business justifies the expenditure. Besides minimizing the can problem, bulk handling has the following advantages:

- Better inventory control by the use of meters
- Less space required for storage
- Outside storage of bulk containers
- Lower costs of many chemicals in bulk
- Less manpower required to move products
- Less physical contact with chemicals

Some possible disadvantages include:

- Cost of equipment
- Inventory carry-over
- Individual pumps and meters required for each chemical to avoid contamination

When weather conditions or other factors prevent some of the pesticide in the applicator tank from being applied, the haulback solution should be added to a holding tank for use at the first opportunity. Agitation will be needed before adding back to the sprayer. A record of the amount of material and its concentration is important to prevent overapplication when the material is reused. Separate holding tanks may be necessary to segregate chemicals used on different crops.

An industrial-type lagoon system can be used to store dilute pesticide rinsewater for reuse (Figure 3). Illinois Pollution Control Board regulations require construction and operating permits from the Illinois EPA to use industrial lagoons for this purpose. Tank rinsings and equipment washwater collected in a surface impoundment and further diluted by precipitation can provide make-up water in mixing new spray solutions. The amount of surface runoff diverted into the impoundment should be limited to prevent overflow. A concrete wash pad will facilitate collection of the rinsewater. Haulback solutions and unused chemicals should not be added to the system.

Recycling through a scrap metal dealer is an alternative to handling five-gallon metal containers. The cans must be *triple-rinsed* before delivery to a recycling facility. Toxicity of pesticide residues is a concern of the scrap metal dealers. Cleaning the containers removes personal risks. Additionally, solvents in some pesticide formulations are excellent grease dissolving agents and tend to interfere with the dealer's processing equipment.

Containers can also be disposed of in a sanitary landfill provided they are triple-rinsed. The standard triple-rinse method or the jet spray process can be used to clean the cans. Several commercial products are available that can be attached to a garden hose for piercing the container as it is emptied and rinsing the inside clean of residues (Figure 4). This jet-spray process has been demonstrated to be equivalent to triple-rinsing by Southern Illinois University researchers, and it is a much faster technique.

Pesticide solutions, rinsates, and residual materials can only be disposed of in a special or hazardous waste landfill. The following procedure is required to dispose of these pesticide-contaminated wastes:

1. The generator of the waste procures a laboratory analysis of the material to be disposed.
2. The lab analysis determines the material contents and hazard classification (toxicity, flammability, etc.). This information is used to ensure that an appropriate landfill is chosen and that required disposal techniques are employed. (The first two steps may be waived if the analysis is predetermined.)
3. The generator selects a landfill for disposing of the waste.
4. The landfill operator files an application with the IEPA Division of Land Pollution Control providing information regarding the generator, hauler, destiny, and disposal methods required for the waste concerned.
5. IEPA reviews the application. Upon approval, an authorization number is assigned and the generator is provided with a six-part manifest (Figure 5).
6. The generator fills out a section of the manifest, providing information on the waste and authorization number. The generator keeps one copy and sends one copy to IEPA.
7. A licensed hauler picks up the waste and four copies of the manifest for transport to the landfill site.

8. The landfill operator accepts the waste, retains one copy of the manifest, gives one copy to the hauler, sends the third copy to IEPA, and returns the original to the generator.
9. The generator reviews the manifest to see that the waste has reached its planned destination and that all signatures and information are provided. He retains this copy.

All manifest records are kept by the generator, hauler, and landfill operator for a minimum of three years.

There are some exceptions to the manifest system. When quantities of acutely hazardous wastes less than one kilogram per month (2.2 pounds) or special wastes less than 100 kilograms per month (220 pounds) are being disposed, no manifest is required; however, the generator is still responsible for seeing that the wastes are disposed in appropriately licensed landfills.

The evaporation pit system appears to be the most practical means of treatment available to date when evaluating cost, safety, and effectiveness. Evaporation pits are impervious tanks or basins that reduce the volume of applied dilute pesticide solutions by evaporation. The pesticide mass may be treated simultaneously by microbial degradation, chemical hydrolysis, and sedimentation.

In dry climates, open pits are effective; however, for areas where rainfall exceeds evaporation, as in Illinois, a translucent roof is recommended.

Concrete or other watertight, nondegradable materials can be used as a liner to prevent leakage. Groundwater monitoring wells are required if the pit cannot be visually inspected for seepage. Sample analyses for the less complex monitoring systems may cost the operator $1,000 a year or more.

Any sludges, pesticide residues, or contaminated soils taken from evaporation pits during cleaning must be disposed of in an approved hazardous or special waste disposal site.

Evaporation pit systems have been field tested by the University of Illinois and Iowa State University. Design and management criteria are available from their respective agronomy and agricultural engineering departments.

Another treatment technique being researched at Southern Illinois University is an acid/alkaline trickling filter system. One trickling filter pit is filled with crushed limestone to promote alkaline hydrolysis. A second pit is filled with strip mine gob to promote acid hydrolysis. Waste herbicide solutions are continuously recycled through the pits by recirculating pumps during a 10- to 20-week treatment period. Preliminary results for the pesticides tested show this system has potential for commercial application.

Other methods have been investigated for treating pesticide waste materials, including microbial degradation, land cultivation, and physical/chemical decomposition. Most are experimental systems that have not been extensively tested at commercial facilities as a part of the daily routine; therefore, potential problems of daily management have not been fully assessed. Plant operators considering the use of a treatment system should review all pertinent technological information available before installation. Also, because treatment systems are subject to state and federal permit requirements, inquiry with the appropriate regulatory agency is advised.

IEPA Policies and Procedures

IEPA inspections of agrichemical facilities have historically been initiated by citizens' complaints or incidents such as fires and spills. Surveillance activities to determine pesticide waste handling procedures are not conducted on a routine basis. Unscheduled visits may occur, however, if a potential pollution problem is observed by IEPA personnel while performing regularly assigned duties.

When an incident occurs or a problem is identified, the situation is reviewed with the plant manager. The IEPA engineer will recommend mitigating actions based on his or her experiences and best professional judgement. The agency first relies on voluntary efforts of the facility operator/owner to get the problem resolved. Enforcement procedures may ensue if positive actions are not taken within a reasonable period of time; however, it is not the desire of the agency to resort to enforcement since it is a negative approach to carrying out its delegated responsibilities.

IEPA prefers to work cooperatively with the custom spray industry in resolving pesticide waste management problems. Technical solutions have not been readily available in the past. Both the agency and the custom operators have gone through an extensive learning experience in recognizing and understanding the issues associated with pesticide waste management. Through accomplishments of the Joint IEPA, Illinois Department of Agriculture, and Industry Task Force, progress has been made in developing guidelines and procedures to minimize pesticide waste handling problems. A continued joint effort will be most effective in overcoming additional problems of mutual concern.

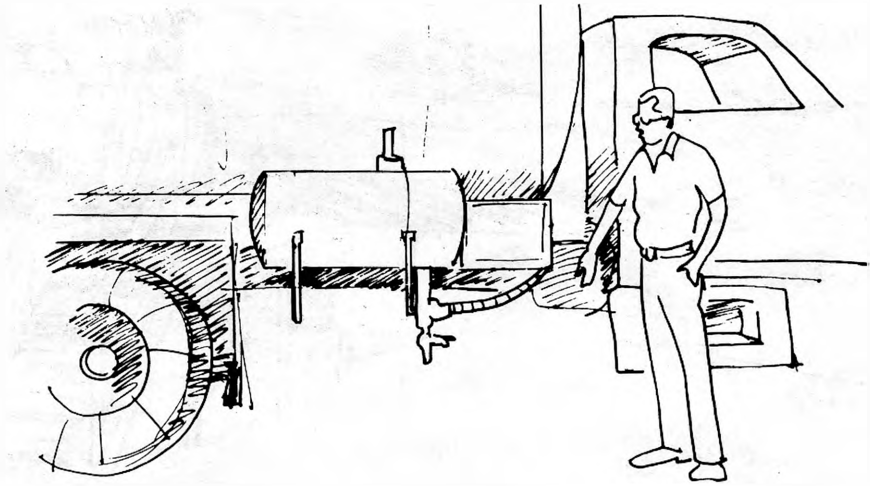
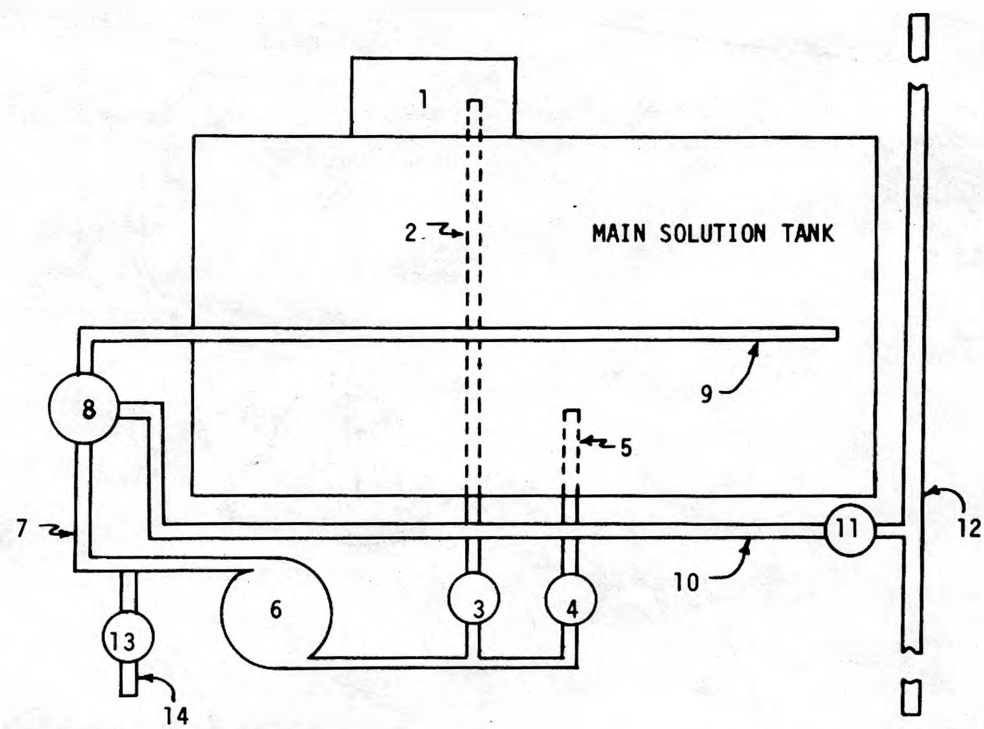


Figure 1. A 50-gallon tank mounted on applicator frame provides a source of water to flush the spray system in the field.



LEGEND

1. 50-gallon water flush tank
2. Hose plumbed to suction side of pump
3. Flush line valve
4. Main solution tank valve
5. Suction line to pump
6. Pump
7. Pressure line to booms or sprayer
8. Dial valve
9. Sparge line inside main solution tank
10. Discharge line to booms or sprayer
11. Boom valve
12. Boom
13. Valve for rinsing hose
14. Rinsing hose

Figure 2. Plumbing schematic for fresh water flush and rinse tank on spray trucks.

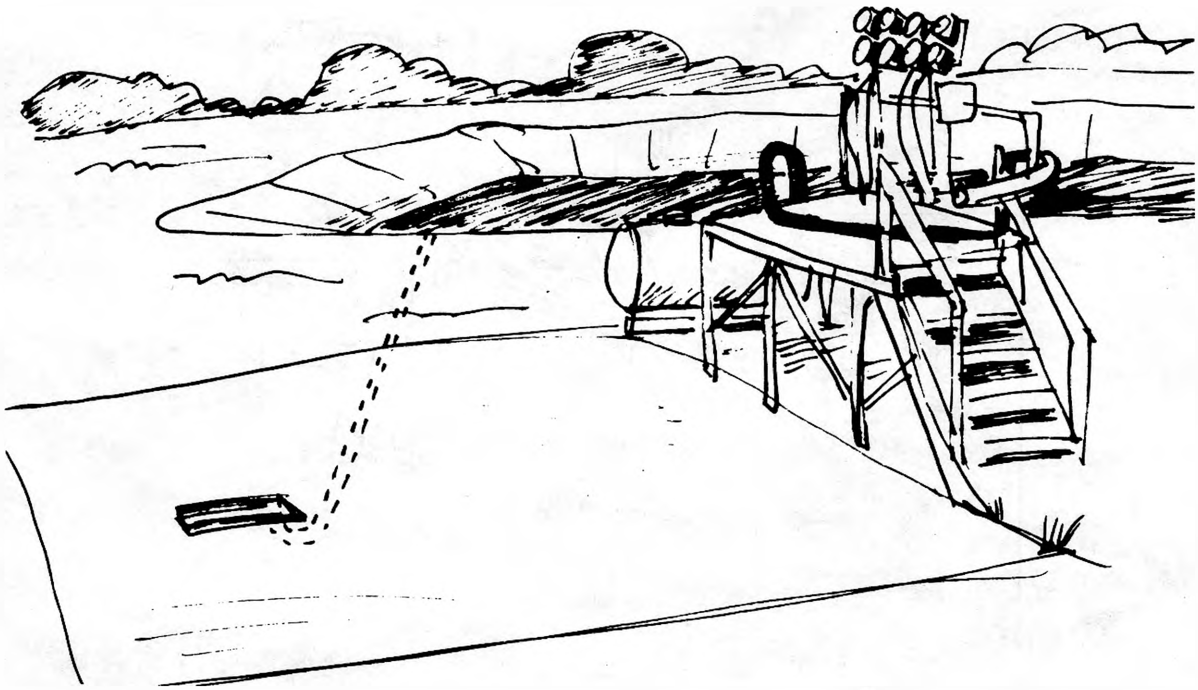


Figure 3. Lagoon storage system for collecting and holding dilute pesticide rinse waters.

Figure 4. Several manufacturers have developed special nozzles for rinsing pesticide containers.

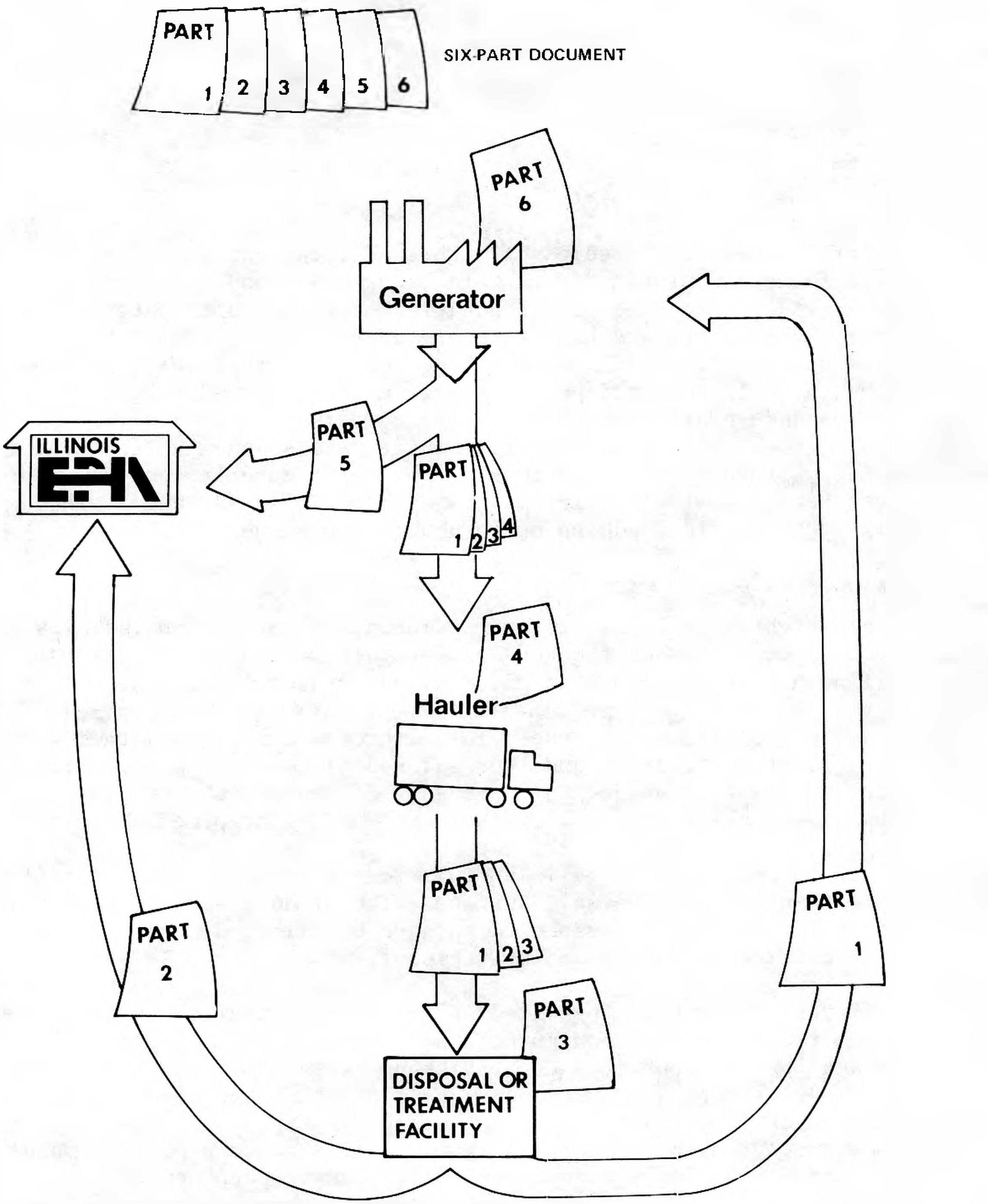


Figure 5. The IEPA manifest system for tracking the transportation of special wastes.

Eastern Black Nightshade

E.L. Knake

Although there are several species of nightshade, the one most commonly causing Illinois soybean farmers a problem is eastern black nightshade (*Solanum ptycanthum*). It is an annual with a branching growth habit. Leaves are alternate on the stem, are one to three inches long, and have variably wavy margins. The leaves tend to be light purple underneath and frequently have holes due to feeding by flea beetles. This feeding may help to distinguish this weed from pigweed, which also has a purple coloration underneath. The flowers are born in clusters and are each about one-fourth inch across. The flower has five white petals and a yellow center. The fruit, or berry, turns from green to dark purple at maturity and is about the same size as a soybean. A single berry may have about 50 seeds, and a single plant may have nearly 1,000 berries, adding up to about 50,000 seeds per plant.

An Increasing Problem

Eastern black nightshade has increased in intensity during the last few years. There has been much speculation on the reasons for this increase. The widespread use of dinitroaniline herbicides has been cited as one reason. These herbicides, such as Treflan, in combination with metribuzin, give relatively good control of many other weeds but do not control nightshade. This improved control of other weeds may have allowed more light penetration and thus allowed black nightshade, which is not considered very tolerant of shade, to increase. Of course, shorter varieties, dry weather, hail, and skips also could result in more light penetration and less shade.

The trend toward reduced tillage is another reason given since the small nightshade seeds are left on or near the soil surface. The trend toward solid-drilled soybeans and less cultivation also is suspected to have contributed, but nightshade has been found in fields with various planting patterns.

A number of agents have been suggested as possibly spreading eastern black nightshade. Among these are farm equipment, manure, and birds. Nightshade seed also may "piggyback" on poor quality seed, sticking to the seed and germinating when the seed is planted. There have been some suggestions that the weather may be influencing the increase in eastern black nightshade since nightshade has seemed to increase in many noncrop areas, but perhaps the flight of birds could explain some of this increase in noncrop areas more than any elusive weather phenomenon. Precise reasons for the spread may remain shrouded in mystery, but the problem has increased and become of considerable concern.

Serious at Harvest

Although competition from nightshade can reduce crop yields, the most serious problem is at harvest. A sticky juice from the nightshade, acting somewhat like glue, can mix with soil, dust, seeds, and other foreign matter and clog a combine. Fewer than one nightshade plant per 10 feet of row can bring harvest to a halt and require down-time for cleaning the equipment.

Unfortunately, nightshade can remain green after soybeans are mature. Although paraquat as a harvest aid may dry its leaves, the green stems and berries can remain until after sufficiently hard frost. Where green patches of nightshade are evident, consider combining around these and perhaps returning to them after the rest of the field is harvested.

In areas of edible dry bean production, such as in Colorado and Michigan, black nightshade has been a problem for many years. The juice from the berries stains the beans, lowering quality and price. There is also the risk of dockage for soybeans stained by the sticky juice and dirt that clings to the seed.

Control

Nightshade is generally not a significant problem in corn. Many of the soil-applied herbicides for corn, such as Eradicane, Lasso, Dual, atrazine, and Bladex, help to control it. Postemergence treatments of atrazine and oil or Bladex are effective. Banvel can also help, and 2,4-D helps to some extent. For fields with a known problem, therefore, one approach would be to plant corn instead of soybeans.

Nightshade seed may germinate relatively early, but under favorable conditions germination may continue for almost the entire growing season. Where a problem is anticipated, planting these fields last can allow delayed seedbed preparation and destruction of any early nightshade. Applying herbicides closer to the time of planting can assure more herbicide near the time of the next flush as well as provide control a little longer into the season.

Lasso, Amiben, and Dual have all helped to control nightshade. Relatively high rates, within allowable limits, can help in initial control as well as in extending the length of control. Combinations of Amiben plus Lasso or Dual can also generally be expected to give control. Preemergence surface applications have often been more effective than preplant-incorporated treatments, providing rainfall is adequate relatively soon after application. Their effectiveness may be due, in part, to the higher concentration of herbicide near the surface where most of the seedlings from this small seed will be emerging. Besides being diluted through incorporation, herbicides applied early preplant do not last as long into the season for control of seedlings from late germinating seed. Lorox as a surface-applied material for the relatively light-colored soils has also been effective.

Although the soil-applied herbicides can help, they do not usually provide 100 percent control. Fields should be closely monitored, and additional measures taken as needed. Cultivations can help. A postemergence application of Blazer can be quite helpful. Field observations suggest that Blazer, in addition to its postemergence activity, may have some soil activity. Postemergence applications should be made so that the spray reaches past the soybean canopy to give good coverage of the nightshade, and applications should be made when nightshade is quite small. Some effect on the soybeans may be noted from Blazer, but this effect is usually rather insignificant compared with the seriousness of nightshade.

Other Crops

Nightshade has not yet been noted as a significant problem in winter wheat or early-seeded spring oats, both of which generally have a competitive advantage. There has been increasing concern, however, about nightshade in forages. For new seedings of some legume forages, Eptam may help during establishment. Princep applied to established alfalfa might be of some help; however, it is doubtful whether there would be a sufficient residual from fall applications for good control the next season.

One of the major concerns in forage crops is the possible poisoning of livestock. Various parts of the plant are reportedly poisonous, with the berries becoming less poisonous as they mature. Apparently, livestock do not generally seek out this plant when other more desirable forage is adequate. Some caution is advisable, however. Reportedly, the poisonous principle remains active in dry hay. Since there has been some confusion about species identification in the literature, additional research on this aspect of eastern black nightshade would be helpful.

There has been occasional concern about plants that appear to have "giant" nightshade-type berries. These plants have been identified as the garden huckleberry (*Solanum intrusum* Soria). It is considered to be related to black nightshade, but the plant is a distinct species that reportedly does not interbreed with the weedy species.

Using Degree Days to Predict Insect Events

S.P. Briggs

Management decisions for insect control are continually being refined and fine-tuned. With improvements in computer technology and systems science, scientists can now simulate insect development on the computer and predict times at which certain pests may become a problem. Growing degree days, degree days, and heat units are terms we often hear and read about. What do they mean and how can the public use these data in insect pest management?

In recent years, entomologists have begun to put more emphasis on temperature accumulation as it applies to insect development. The reasoning is that environmental temperature almost exclusively controls the rate of physiological development in insects (Ruesink 1981). Since insects are "cold-blooded" animals, their body temperature is controlled by the temperature around them. As air temperatures rise, body functions such as rate of maturation, rate of reproduction, and rate of feeding all increase. Insects all have a minimum temperature at which development is ceased. This temperature, which varies with each insect, is termed the "threshold temperature." Above this threshold temperature the rate of maturation from the immatures to adult for many insect species is approximately a linear function when temperatures are in the range of 50 to 80° F.

For example, a species with a threshold temperature of 50° will develop twice as fast at 70° as at 60°. Given these facts, a "degree day" is the amount of heat accumulated in one day when the temperature is one degree above the threshold (Ruesink 1981). The mathematical formula for calculating degree days is very simple. It is:

$$\text{Degree day} = \frac{\text{maximum temperature} + \text{minimum temperature}}{2} - \text{threshold temperature}$$

Example 1. The alfalfa weevil threshold temperature is 48° F. If on April 2nd, the maximum temperature was 70° F. and the minimum temperature was 50° F., how many degree days were accumulated on this day?

$$\text{Degree days} = \frac{70 + 50}{2} - 48 = 12$$

In Example 1, degree days are calculated for the alfalfa weevil. This calculation is done each day, and each daily total is then added to the previous cumulative total. If temperatures *never* reach above the threshold, the number of degree days accumulated for that day is zero. We *never* take degree days away from our total, since insect development stops below the threshold but does not regress backwards.

Another term that we often see used interchangeably with degree days is heat units. Although degree days and heat units are fairly similar, the calculations for each differ. Most entomologists use heat units because the calculations are based on a sine wave function that closely approximates the variable temperature through a 24-hour time period (Allen 1976). Heat units also are more accurate when the daily temperatures are close to the threshold temperature. For example, we know that on a typical spring morning the temperatures are cool. As the day progresses, the temperature rises to a peak temperature in midafternoon. During the evening and early morning hours, temperatures drop. What has just been described is roughly the shape of a sine-wave (Figure 1). By calculating the area or units above the threshold we can approximate the accumulated heat units for that location.

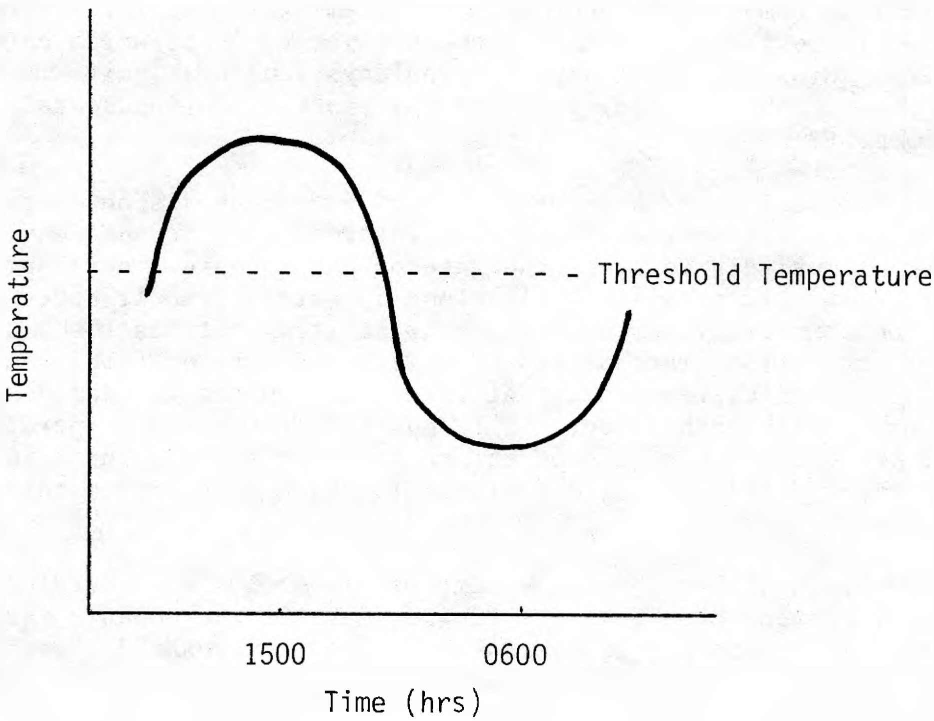


Figure 1. Fluctuation of temperatures over a 24-hour period.

Growing degree days are widely used by agronomists to approximate the growth of the corn or soybean plant. The growing degree days are calculated as follows:

1. Take the daily maximum temperature (not to exceed 86° F.).
2. Take the daily minimum temperature (not to be below 50° F.).
3. Add the maximum value and the minimum value, and divide by 2.
4. Subtract 50 from the value obtained in step 3. The resulting value is your growing degree days.

Example 2. If the high temperature on May 28 was 81° and the low was 51°, how how many growing degree days (GDD) were accumulated?

$$GDD = \frac{81 + 51}{2} - 50 = 66 - 50 = 16$$

Sixteen growing degrees were accumulated.

$\boxed{\text{Example 3.}}$ If the high temperature on May 30 was 92° and the low was 52°, how many growing degree days (GDD) were accumulated?

$$GDD = \frac{86 + 52}{2} - 50 = 69 - 50 = 19$$

Nineteen growing degree days were accumulated. *Note*: the maximum temperature exceeded 86° F. We therefore only entered 86°.

Forecasting

Research on specific insects has revealed the number of degree days or heat units it takes for these insects to complete their various life stages. By knowing these numbers and calculating the accumulated degree days for a particular location and the development of the host plant, we can forecast when populations will reach a damaging stage.

For those insects that overwinter as eggs or adults in Illinois (for example, corn rootworms, alfalfa weevil, and grasshoppers), predictions are based on degree days accumulated from January 1. For other insects, such as black cutworms and green cloverworms, an initial event must take place before we start accumulating degree days for further predictions. For example, after the first moth flight of the season has been recorded for black cutworms, we can then predict when the eggs will hatch and when the cutting of plants will begin. Degree days play a major role in the black cutworm prediction model developed in Illinois.

Table 1 lists those insects commonly found in Illinois, their threshold temperatures, and the day or event that signals the start of degree day accumulation.

Tables 2 and 3 show the development of seven commonly found insects in Illinois according to degree-day accumulation. These were assembled by Dr. William G. Ruesink of the University of Illinois and Illinois Natural History Survey. They are intended to act only as a guide to insect development, because events will vary slightly each year. Dr. Ruesink and others are continually working to refine the computer models that predict insect development.

Summary

Models that describe insect development are becoming an important tool in insect pest management. Knowing when and possibly how large an infestation will be are valuable pieces of information. Given in this paper are definitions, explanations, and examples of degree days, heat units, and growing degree days. Two tables illustrate seven insects and their developmental rate according to degree-day accumulation. By observing these pests each year, we can refine the information found in these tables.

References Cited

Allen, J.C. A modified sine wave method for calculating degree days. Environ. Entomol. 5(3):388-96; 1976.

Ruesink, W.G. Some insect pest management systems that utilize weather data. Weiss, A, ed. Computer techniques and meteorological data applied to problems of agriculture and forestry: a workshop; Anaheim, Ca.; 1981; 257-64.

Table 1. Threshold Temperatures for Commonly Found Illinois Insects

Insect	Threshold temperature (F°)	Starting day for accumulation of degree days
Alfalfa weevil	48	January 1
Corn rootworms	44	January 1
Grasshoppers	50	January 1
Black cutworm	50	At first moth flight
European corn borer	50	At first moth flight
Green cloverworm	52	At first moth flight
Bean leaf beetle	50	Planting day of soybeans

Table 2. Predictions of Insect Activity Based on Degree-Day Accumulation from January[a]

Degree days from Jan. 1	Alfalfa weevil (base 48° F.)	Corn rootworm (base 44° F.)	Grasshoppers[b] (base 50° F.)
100			
200	Larvae present		
300	Start sampling		
400			
500	Best spray date (450)		Hatch
600	Peak larval feeding		
700			
800		Egg hatch	
900	1st harvest		
1000			2nd instar
1100	Peak new adults		
1200			
1300			3rd instar
1400			
1500		Peak larval feeding	
1600			
1700			4th instar
1800			
1900			
2000		Adult emergence	
2100			
2200			

[a]Prepared by Dr. W.G. Ruesink, University of Illinois and Illinois Natural History Survey.

[b]For grasshoppers, the entry indicates that 25 percent of the population is this stage or older.

Table 3. Predictions of Insect Activity Based on Degree-Day Accumulation Following an Observed Initial Event[a]

Degree days from event	Black cutworm (base 50° F.)	European corn borer (base 50° F.)	Green cloverworm (base 52° F.)	Bean leaf beetle (base 50° F.)
0	Moth flight	Moth flight	Moth flight	Planting
100	Egg hatch			Colonizers
200		1st instar		
300	Cutting begins			
400			5th instar	
500	Peak cutting			
600				
700				
800		5th instar		
900			2nd moth	
1000			flight	
1100				
1200				1st generation
1300		2nd moth		adults
1400		flight		
1500			5th instar	
1600				
1700				
1800				
1900				
2000		3rd instar		
2100			3rd moth	
2200			flight	
2300				2nd generation
2400				adults
2500				
2600				

[a]Prepared by Dr. W.G. Ruesink, University of Illinois and Illinois Natural History Survey.

Postemergence Grass Weed Control in Soybeans

J.J. Velovitch

The new postemergence grass herbicides for soybeans will, I believe, put growers in a similar era as 2,4-D did in the 1950s. Postemergence weed control is a growing concept, and the excitement that these chemicals have generated has been heightened even further with the anticipated market availability of at least one or two of these herbicides in 1983.

The postemergence herbicides have many advantages compared with the more conventional preplant-incorporated or preemergence soil treatments that have been used consistently in the past. For example, the efficacy of the postemergence herbicides is not influenced by soil conditions such as soil texture, organic matter, and crop residue. Postemergence herbicides are also less dependent on the weather. Rain is not required to "activate" the chemicals, as it is with some soil treatments. In fact, the new compounds are very rain resistant, that is, they do not wash off the leaves because their penetration into the plant is very rapid, usually within a few hours.

The new postemergence herbicides should also give more consistent control. Failure to perform is nearly impossible if they are applied according to label directions. Their use should, moreover, reduce concern about "purple corn syndrome," which may be caused by dinitroaniline (DNA) carryover. (DNA carryover is not the only factor responsible, however, for purple corn syndrome.) The new compounds also should lessen the "pressure-planting situation." Farmers will not have to be concerned about herbicide treatment at the same time they are under pressure to till and plant. Nevertheless, postemergence treatments will extend the early season workload.

Finally, the new postemergence herbicides should eliminate streaking in grass control. There is little doubt that reduced incorporation of soil-applied herbicides has significantly reduced our grass control. The standard by which the new herbicides will be judged, therefore, will be whether they equal or better the present control now offered by single-pass incorporation of preplant-incorporated or preemergence herbicides.

Postemergence grass control is a concept that has the potential to change our weed control strategy. This concept combines well with the major changes in soybean production practices in recent years. More acreage continues to be planted to both no-till and reduced-till soybeans. In the future, the government may mandate reduced tillage in an effort to minimize soil erosion losses. These changes in tillage practices will continue to push the postemergence concept even further.

Changes in cropping practices, such as narrower rows and doublecropping, continue to increase. If this trend continues, postemergence will become a necessity, not an option, since mechanical cultivation is not feasible. The narrow-row practice also aids grass control since the canopy becomes established much earlier than in conventional rows, thus shading the soil and suppressing the germination of the grass weed seeds.

Growers are beginning to realize that it simply makes more sense to wait and see if a grass problem develops rather than to treat acreage, perhaps unnecessarily, for a problem that may not exist. This "wait-and-see" attitude has been promoted by our ongoing efforts toward a sound integrated pest management approach to crop production.

All of these new compounds work similarly in that they are very rapidly absorbed by the leaf and are transported downward to the growing point and root portions of the plant. Grass growth is halted almost immediately, although the leaves appear green and healthy initially. Within 10 to 14 days, however, the inner whorl appears dead, and it is only a matter of time before the entire plant withers and dries. Similar symptoms appear on volunteer corn, and the treated corn plant may subsequently lodge, thus preventing harvesting difficulties in the soybean field.

All of the new herbicides are extremely active on annual grass species such as giant foxtail, volunteer corn, goosegrass, panicum, barnyardgrass, and wild cane and on perennial species such as johnsongrass in southern Illinois and quackgrass in northern Illinois. All broadleaf weeds and crops are tolerant of the new herbicides, and some soil residual activity has been demonstrated. A major advantage is that the efficacy of control is independent of the growth stage of the grass, and, in fact, superior grass control has been achieved by treating grass at a later stage of growth rather than at an early stage. This late treating allows ample time for maximum weed seed germination and emergence so that there is a larger leaf area exposed for the foliar herbicide treatment. Growers do not risk a yield reduction by allowing grasses to germinate and establish, as long as the grass competition is eliminated within about four weeks after emergence. This option of delaying application affords growers much flexibility in their operations.

This year, we evaluated six experimental herbicides in addition to Hoelon (dichlofop). Postemergence treatments were made to giant foxtail at two stages of growth: at approximately two inches tall (two-leaf stage) and at seven to eight inches tall (four- to five-leaf stage). Metribuzin was applied to minimize broadleaf weed competition. Experimental herbicide rates ranged from one-half to four ounces active ingredient per acre. All treatments consistently gave over 90 percent grass control. In all treatments, crop oil concentrate (COC) was added to enhance penetration into the plant. All of the potential postemergence herbicides will require an adjuvant, such as a COC or a nonionic surfactant.

Several of these herbicides are near completion of registration and should be available soon. Both Poast (sethoxydim) and Fusilade (fluazifop-butyl) have been granted Section 18 exemptions (Emergency Use Permits) by the EPA for use on soybeans. Both of these compounds are presently being marketed abroad.

The results from our field studies in 1982 are very encouraging, and we may anticipate continued efforts toward the postemergence concept in the future.

Demonstration Test Results with Rootworm Insecticides

K.L. Steffey

In 1982 we conducted fourteen trials to evaluate the efficacy of soil insecticides for corn rootworm control. These tests, conducted with the assistance and cooperation of county Extension advisers and farmers, were located in Boone, Champaign, DeKalb, Ford, Henry, Kane, Kankakee, LaSalle, McHenry, Piatt, Ogle, Shelby, and Whiteside counties. The objective was to evaluate root damage and yield to determine the level of rootworm control provided by the commonly used rootworm insecticides. Another objective in two of the trials was to determine what effects, if any, tillage had on the efficacy of rootworm insecticides.

Materials and Methods

The soil insecticides evaluated in these trials were isofenphos (Amaze 20G), terbufos (Counter 15G), fonofos (Dyfonate 20G), carbofuran (Furadan 15G), chlorpyrifos (Lorsban 15G), ethoprop (Mocap 10G), bendiocarb (Rotate 10G), and phorate (Thimet 20G). All of these granular insecticides were applied at the rate of one pound of active ingredient per acre (a.i./A) based on 40-inch row spacings.

Two types of trials were conducted in 1982. Twelve of the tests are referred to as large-scale yield trials, and the other two tests are called small-scale demonstration plots. Plot size and application equipment were different for the two types of trials. In addition, one of the large-scale trials and one of the small-scale plots were developed as tillage studies.

Large-Scale Yield Trials

These tests were designed so that farm equipment could be used to plant and harvest the corn. Each treatment was applied to four rows 200 feet in length. The experimental design used was a randomized complete block with four replications in eleven of the plots and three replications in the University of Illinois (UI) field. An untreated check was included in each replication. The seven currently recommended materials were evaluated in all but the UI field.

Corn was planted in eleven of the plots with an International Harvester Model 56 two-row planter. The insecticides were metered through Gandy granule applicators and applied in a seven-inch band ahead of the planter press wheel. The granules were incorporated with drag chains mounted behind the press wheels. Application methods at the UI location are discussed in the "Tillage Studies" section.

Small-Scale Demonstration Plots

Each treatment was applied to a single row 65 feet in length in Boone County and 150 feet in length in Kane County. The experimental design used was a randomized complete block with four replications. An untreated check was included in each replication. All of the currently recommended compounds were evaluated in each trial.

Each insecticide was applied in a seven-inch band over the row by means of a Noble metering unit mounted on a bicycle-wheeled applicator. The granules were lightly incorporated with a rake.

Tillage Studies

The effects that different tillage practices have on the efficacy of rootworm insecticides were evaluated at the University of Illinois and in Boone County. The tillage practices in the large-scale yield trial at the UI location were: (1) conventional fall plow, (2) fall disk, and (3) no-till. The tillage treatments in the small-scale demonstration plot in Boone County were: (1) spring plow, (2) spring chisel, and (3) no-till.

At the UI location, the corn was planted with a John Deere 7000 Series planter. The insecticides were applied in a seven-inch band ahead of the firming wheels and were incorporated with tines mounted behind the firming wheels. Each treatment was applied to four rows 150 feet in length and replicated three times in a randomized complete block. This design was duplicated in each of the three tillage treatments. Counter 15G, Furadan 15G, Lorsban 15G, and an untreated check were included in each replication.

The experimental design and insecticide application methods at the Boone County location were the same as for the other small-scale demonstration plots. However, the insecticides were not incorporated in the no-till plot. A complete small-scale plot, including eight insecticides and a check, was established in each of the tillage treatments.

Evaluation Methods

Root systems from each treatment in every replicate were examined and rated for rootworm damage. The sample size was five plants per treatment per replication in the small-scale plots and ten plants per treatment per replication in the large-scale trials. The root rating system we used to evaluate the treatments follows:

Root rating	Degree of damage
1	No visible damage or only a few minor feeding scars.
2	Some roots with feeding scars but none eaten off within 1½ inches of the plant
3	Several roots eaten off to within 1½ inches of the plant but never the equivalent of an entire node of roots destroyed.
4	One node of roots destroyed or the equivalent.
5	Two nodes of roots destroyed or the equivalent.
6	Three or more nodes of roots destroyed.

Results

The rootworm pressure in most of the trials conducted in 1982 was light. The average root ratings in the untreated checks were less than 3.0 in the trials in DeKalb, Ford, Henry, Kane (Radtke), LaSalle, and Piatt counties. Data collected from these fields are not included because the rootworm infestations were not economic.

The results of the root rating evaluations from trials in which the average root ratings in the untreated checks were 3.0 or greater are presented in Tables 1 to 3. At the time this manuscript was in preparation, the yields from the large-scale trials were not available.

The average root ratings in the untreated checks at all locations except the UI field (Table 3) were between 4.0 and 4.55. These root ratings suggest that rootworm damage was moderate in five of six trials. During most years, a root rating of 3 or more is considered to lead to economic damage. However, the plentiful moisture available to corn root systems during the summer of 1982 was ideal for root regrowth. Many damaged root systems regenerated a lot of roots. The effect that root regeneration has on yield is not yet known.

Overall, the rootworm insecticides provided adequate root protection (root rating less than 3) in most of the trials. However, Thimet 20G was erratic in its performance. It failed to provide adequate control in McHenry and Ogle counties (Table 1) and in the plowed plot in Boone County (Table 3). Lorsban 15G provided only marginal control in the McHenry County plot.

Furadan 15G performed well in 1982 in fields with a history of organophosphate use (McHenry and Ogle counties in Table 1, and Boone County in Table 3). Furadan performed marginally in fields that had experienced problems with Furadan in the past (Kankakee and Shelby counties in Table 1, and University of Illinois in Table 3).

The results of the tillage studies are presented in Table 3. The rootworm pressure was heavy at the UI location and in the plowed plot in Boone County. The infestations in the chiseled and no-till plots in Boone County were very light. The infestation in the no-till plot at the UI location was slightly lower than in the plowed and disked plots. These data suggest that rootworm pressure may be lower in reduced tillage fields than in conventionally plowed fields. Although the literature somewhat supports this statement, the effect of tillage on rootworm populations is still not known. Only two years of data have been collected, so the research is incomplete. Studies in the future will be aimed at determining the effect that tillage has on both rootworm populations and rootworm insecticide performance.

Conclusions

Specific recommendations for control of corn rootworms are presented in the *1982 Insect Pest Management Guide: Field and Forage Crops* in the "Insect Recommendations" section of this manual. Generally, in fields where the rootworm pressure is light to moderate, all of the recommended materials will provide adequate control. In fields where the rootworm pressure is heavy, some chemicals will provide better control, in terms of root protection, than others.

Acknowledgements

We wish to express our thanks and appreciation to the following county Extension advisers and farmers for their assistance and cooperation in conducting these trials:

Boone County:	Wallace Reynolds, Extension adviser, and Don Ellingson
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Henry County:	Dean Oswald, Extension adviser, and Robert Sipp

Kane County:	Bill Whiteside, Extension adviser, John Radtke, and Frank Hartman
Kankakee County:	Dave Whitson, Extension adviser, and Wes Peters
LaSalle County:	Dave Dimmik, Extension adviser, and Bob Hughes
McHenry County:	Brian Sager, Extension adviser, and John Bartman
Piatt County:	Don Smucker, Extension adviser, Mike Ferguson, and Lynn Larson
Ogle County:	Stan Eden, Extension adviser, and Bob Groenhagen
Shelby County:	Ed Ballard, Extension adviser, and Orlando Bohlen
Whiteside County:	Dave Feltes, Extension adviser, and Jon Kophamer

Table 1. Corn Rootworm Control in Large-Scale Demonstration Trials, Illinois, 1982

	Mean root ratings*			
Treatment	Kankakee County	McHenry County	Ogle County	Shelby County
Amaze 20G	2.83† ab	1.70 a	1.78 ab	1.93 a
Counter 15G	1.80 a	2.33 b	1.97 b	2.40 ab
Dyfonate 20G	1.93 a	2.88 c	1.93 b	2.70 ab
Furadan 15G	2.88 ab	1.35 a	1.16 a	2.93 b
Lorsban 15G	2.03 a	3.35 d	1.66 ab	2.95 b
Mocap 10G	2.65 a	2.70 bc	2.18 b	2.05 a
Thimet 20G	2.22 a	3.40 d	3.05 c	2.43 ab
Check	4.08 b	4.40 e	3.05 c	4.25 c
Insecticide history**	FF	OP	OP	FF

*Means are based on 40 observations (10 roots per treatment times four replications). The root damage rating scale includes six categories, ranging from no damage (1) to severe damage (6). Means followed by the same letter do not differ significantly at the five percent level (Duncan's Multiple Range Test).

†Amaze 20G was misapplied in one replication.

**Abbreviations for insecticide history are as follows: OP = only organophosphates used; FF = Furadan failure within last seven years.

Table 2. Corn Rootworm Control in a Small-Scale Demonstration Plot, Illinois, 1982

Treatment	Mean root ratings* Kane County (Hartman)
Counter 15G	1.45 a
Amaze 20G	1.65 ab
Thimet 20G	1.75 abc
Dyfonate 20G	2.00 abc
Rotate 10G	2.10 bc
Landrin 15G	2.15 bc
Mocap 10G	2.25 bc
Furadan 15G	2.30 c
Lorsban 15G	2.35 c
Check	3.10 d

*Means are based on 20 observations (five roots per treatment times four replications). The root damage rating scale includes six categories, ranging from no damage (1) to severe damage (6). Means followed by the same letter do not differ significantly at the five percent level (Duncan's Multiple Range Test).

Table 3. Corn Rootworm Control in Different Tillage Systems, Illinois, 1982

	Mean root ratings*					
	Boone County			University of Illinois		
Treatment	Plow	Chisel	No-till	Fall plow	Fall disk	No-till
Amaze 20G	2.35 ab	1.80 ab	1.55 a			
Counter 15G	1.95 ab	1.95 ab	1.50 a	2.07 a	3.07† a	2.27 a
Dyfonate 20G	2.05 ab	2.20 ab	1.75 ab			
Furadan 15G	1.60 a	1.70 ab	1.70 ab	2.90 a	2.93 a	3.23 a
Lorsban 15G	2.95 bc	2.35 b	2.15 bc	3.30 a	3.00 a	2.27 a
Mocap 10G	2.60 ab	2.15 ab	1.70 ab			
Rotate 10G	2.05 ab	1.60 a	1.25 a			
Thimet 20G	3.75 cd	2.00 ab	1.70 ab			
Check	4.55 d	3.10 c	2.50 c	4.93 b	5.07 b	4.47 b

*The root damage rating scale includes six categories, ranging from no damage (1) to severe damage (6). Means followed by the same letter do not differ significantly at the five percent level (Duncan's Multiple Range Test). Means are based on 20 observations (five roots per treatment times four replications) in Boone County and 30 observations (10 roots per treatment times three replications) at the University of Illinois.

†Counter 15G was misapplied in one replication.

Wheat Disease Control Using Seed Treatment and Foliar Fungicides

B.J. Jacobsen

The use of fungicides on wheat has largely been limited to seed treatment materials. These materials have given good to excellent control of bunt, loose smut, and seed decay fungi, and they have given partial control of Septoria glume blotch, Fusarium seedling blight, and seedborne "Helminthosporium" diseases.

During the 1960s the use of foliar fungicides became standard in disease control programs in Europe. Their use also was adopted by wheat producers in Minnesota and North Dakota for control of Septoria leaf and glume blotch. It is expected that the use of foliar fungicides will increase in Illinois. This increase is expected because of several factors, including higher-yielding varieties, higher rates of nitrogen fertilization, better fungicides with an increased spectrum of disease control, and an increased recognition of losses caused by foliar diseases such as leaf rust, powdery mildew, and Septoria leaf blotch and by head diseases such as scab and Septoria glume blotch.

Seed Treatment Fungicides

The advantages of fungicide seed treatments are well documented in terms of increased yields and grain quality. Our research since 1974 has shown that treated seed consistently yields three to four bushels per acre more than untreated seed. These higher yields are primarily the result of increased control of seed decay and seedling blight fungi and bunt and loose smut diseases.

Seed decay and seedling blight diseases in Illinois are caused by fungi such as Rhizoctonia, Pythium, and Fusarium. Fusarium seedling blight is another phase of scab disease and is the most important seedling disease in Illinois. Seedlings grown from Fusarium-infected seed are often killed in the winter or tiller poorly.

The bunt and loose smut diseases have been kept under control through the use of effective seed treatment fungicides and resistant varieties. Because the loose smut fungus infects the embryo, a systemic fungicide is needed for control. Carboxin, the only labeled systemic fungicide, is thus the only fungicide available for loose smut control. Although smut diseases are at noneconomic levels at present, it should be remembered that these levels have been achieved through the widespread use of carboxin-containing fungicides and loose-smut-resistant varieties.

Table 1 lists the labeled seed treatment fungicides and their relative effectiveness in control of seed decay, seedling blight, and smut diseases. Results of 1981 to 1982 seed treatment trials can be found in Table 2.

Based on this and previous years' research the fungicide Baytan® (Mobay) appears to be a promising seed treatment fungicide. This fungicide gives good to excellent control of bunt and loose smut and fair to good control of seed decay and seedling blight fungi. Baytan also provides fair to good control of take-all and provides some control of both powdery mildew and rust the following spring. Label clearance for this product is expected before next fall.

Six to nine percent of the seed lot used in the 1981 to 1982 wheat seed treatment study was infected with the Fusarium (scab) fungus. The data in Table 2 show that higher rates of Vitavax 200 are advantageous in controlling scab seedling blight.

Foliar Fungicides

Illinois wheat producers suffered 15 to 20 percent yield losses due to leaf rust disease in 1982 and similar losses to Septoria diseases in 1973, 1974, and 1975. Table 3 summarizes the yield losses to foliar and head scab diseases for the period 1973 to 1982. It should be noted that losses are not cumulative since a leaf or plant can be killed only once.

Table 3 shows that in 5 of the last 10 years producers would have increased yields 5 to 10 percent or more through the use of a foliar fungicide program. The choice of fungicide and the timing of application will differ slightly based on the disease that is limiting yield and the yield potential in a particular field. At present, only zineb and mancozeb (Dithane M45 [Rohm and Haas] and Manzate 200 [DuPont]) are labeled for use on wheat for control of the Septoria diseases and leaf rust. During 1981 and 1982, emergency registration (Section 18) was obtained for Bayleton (Mobay) for control of powdery mildew (1981) and leaf rust (1982). Additionally, a section 18 registration was obtained for Benlate and Manzate 200 (DuPont) in 1981 for powdery mildew and Septoria control. These emergency registrations have both expired and should soon be replaced with full federal labels.

Results of the 1982 foliar fungicide trials are found in Table 4. In these trials, Bayleton and Dithane M45 (mancozeb), either alone or in combination, gave good control of the leaf rust and Septoria leaf and glume blotch diseases. Yields were increased significantly by these and several other treatments.

Head scab control was not statistically significant in 1982 tests. Significant control has been achieved in prior years, however, with Benlate and mancozeb sprays. It is anticipated that seed producers will be able to use this fungicide combination in 1983 if head scab threatens.

The newer foliar fungicides Bayleton and Benlate, alone or in combination with mancozeb, are powerful new tools in the control of foliar wheat diseases. The need for these tools is shown by the serious losses that have occurred in the past 10 years. New races of leaf rust or powdery mildew, higher nitrogen and seeding rates, and changes in wheat culture suggest that foliar fungicides will play an ever increasing role in Illinois wheat production.

Table 1. Wheat Seed Treatment Fungicides: Effectiveness of Control

Common name	Trade name	Seed decay, seedling blights	Bunt	Loose smut
Captan	Orthocide	good	poor	none
Carboxin	Vitavax	fair	good[a]	excellent
Maneb		good	poor	none
HCB		poor	excellent	none
Thiram		good	poor	none
Maneb-HCB	Granox NM	good	excellent	none
Carboxin & Captan	Orthocide-Vitavax 20:20	good	good[a]	excellent
Carboxin & Thiram	Vitavax 200	good	good[a]	excellent
PCNB	Terraclor, Terracoat LT2	good	good	none
PCNB & Etridiazol	Terracoat L21 L205, DE 20	good	good	none

[a]High label rates are necessary for good control (one ounce of active ingredient per hundredweight).

Table 2. Results of 1981 to 1982 Winter Wheat Seed Treatment Trials[a]

Treatment	Rate (oz./cwt.)	Percent germination on potato dextrose agar	Percent fusarium infection	Yield (bu./A)	Average number of tillers per meter	Average plant height
Vitavax 200FF with Phase II binder	4.0	84.0	0	65.45**	133	77
Vitavax 34F	2.0	77.5	7.0	63.9*	140	81
Vitavax 34F + Captan 30DD	2.0 + 1.52	87.5	1.5	65.10*	132	81
Baytan Flowable (0.3 lb./gal.)	3.3	86.0	5.0	69.0***	138	81
Vitavax + Baytan (0.3 + 0.3 lb./gal. flowable)	3.0	86.5	3.0	63.45	141	81
Vitavax + Baytan + Mancozeb (0.3 + 0.3 + 0.3 lb./gal.)	3.0	92.5	2.0	61.18	139	80
Vitvax + Mancozeb (1.67 + 1.67 lb./gal.)	4.0	85.5	2.5	70.5***	143	77
Furmecyclox (4.0 lb./ gal.)	1.67	83.0	1.5	67.35***	131	78
Vitavax 200 + Metalaxyl	3.3 + 1.0	73.0	2.5	67.85***	143	79
Vitavax 200 + Metalaxyl	4.0 + 1.0	87.5	0	63.20	144	79

Table 2. (Continued)

Treatment	Rate (oz./cwt.)	Percent germination on potato dextrose agar	Percent fusarium infection	Yield (bu./A)	Average number of tillers per meter	Average plant height
Apron	1.0	84.5	8.5	62.90	140	79
CGA-64251 0.846 EC	0.33	89.5	7.0	59.40	126	83
Apron 2E + CGA-64251 0.846 EC	1.0 + 0.33	83.5	5.0	67.10***	141	83
Untreated	--	82.5	6.0	58.0	132	79
TF 3090 P (Maneb-50%)	1.0	98.0	2.0	57.60	142	81
TF 3090 P (Maneb-50%)	1.5	88.5	2.5	58.30	142	80
TF 3240 F (Maneb-25%)	1.66	90.5	7.5	67.0***	135	77
TF 3250 F (Maneb-25%)	2.5	81.0	7.5	61.80	150	80
Granox F (Maneb-25% + HCB-5%)	1.7	83.5	7.0	68.15	134	81
Untreated	--	87.5	9.0	57.9	130	82
Baytan 150 FS R1	0.5	87.0	9.0	66.45**	138	80
Baytan 150 FS R2	1.0	80.0	2.0	64.35*	147	81

[a]The variety used was Hart. The plot was located in Urbana, Illinois.
*Significant at P = .80
**Significant at P = .90
***Significant at P = .95

Table 3. Percent Yield Losses to Septoria Leaf and Glume Blotch, Leaf Rust, Powdery Mildew, and Head Scab Diseases, 1973 to 1982

Diseases	Percent yield losses									
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Septoria leaf & glume blotch	10-15	15-20	10-15	<1	<5	<1	<5	<5	<5	5-10
Leaf rust	<1	<1	<1	<1	<1	1-2	1-2	1-2	<5	15-20
Powdery mildew	<1	<1	<1	<1	<1	<1	<1	<5	5-10	5
Head scab	5-10	5-10	5-10	<1	<5	<1	<1	<1	5-10	5-10

Table 4. Results of 1982 Wheat Foliar Fungicide Tests[a]

Treatment	Growth stage at application(s)	Rate (a.i./A)	Yield (bu./A)	Disease ratings: Flag leaf, Percent leaf rust	Disease ratings: Flag leaf, Percent Septoria	Disease ratings: Flag minus leaf, Percent Septoria	Percent Fusarium in seed
Untreated	-	-	64.0	1.76	1.7	25.0	32.0
CGA-64250 3.6E	8	50 gm.	63.4	1.17	1.36	9.5	26.0
CGA-64250 3.6E	8	75 gm.	74.4	7.3	1.1	11.9	25.0
CGA-64250 3.6E	8, 10.1	50 gm.	72.8	0.67	1.2	11.7	18.7
CGA-64250	10	50 gm.	69.6	9.3	1.03	16.6	25.0
CGA-64250	10	75 gm.	78.3	1.3	1.43	6.4	22.0
Benlate	8, 10.1	1/4 lb.	68.8	1.16	4.13	31.13	20.0
Dupont	8, 10.1	1 oz.	76.1	1.27	8.93	31.6	40.3
Dupont	8, 10.1	2 oz.	62.1	1.17	2.03	36.36	37.0
Dupont	8, 10.1	4 oz.	72.9	0.77	1.07	12.43	58.0
Benlate + Dupont	8, 10.1	1/4 lb. + 1 oz.	70.8	1.2	6.13	20.3	26.7
Benlate + Dupont	8, 10.1	1/4 lb. + 2 oz.	65.5	0.8	1.07	35.17	24.7
Benlate + Dupont	8, 10.1	1/4 lb. + 4 oz.	76.4	0.77	0.77	22.17	45.7
Dithane M45	8, 10.1	1.6 lb.	75.0	1.5	0.63	6.5	35.0
M-822 F	8, 10.1	1.6 lb.	69.0	0.97	1.83	14.97	26.3
Dithane 45 + Topsin M	8, 10.1	1.0 lb. + 0.2 lb.	72.5	0.87	1.47	25.76	39.0
RH-5781F	8, 10.1	0.2 lb.	74.4	1.13	2.47	27.6	37.0
RH-5781F	8, 10.1	0.4 lb.	81.4	1.03	0.47	10.63	39.7
RH-5781F	8, 10.1	0.2 lb.	71.6	0.97	0.83	15.7	38.0
RH-5781F	8, 10.1	0.4 lb.	82.2	0.93	2.07	23.17	30.0
RH-5781F + Dithane M-45	8, 10.1	0.2 lb. + 1 lb.	80.0	0.63	0.53	14.16	30.7
RH-5781F + Dithane M-45	8, 10.1	0.4 lb. + 1.0 lb.	83.4	0.57	0.50	13.83	33.0
Bayleton	8	1 oz.	85.1	1.56	2.83	40.43	29.0
Bayleton	8	2 oz.	84.6	1.30	1.05	14.66	31.7

Table 4. (Continued)

Treatment	Growth stage at application(s)	Rate (a.i./A)	Yield (bu./A)	Disease ratings: Flag leaf: Percent leaf rust	Disease ratings: Flag leaf: Percent Septoria	Disease ratings: Flag minus leaf: Percent Septoria	Percent Fusarium in seed
Dithane M-45	8, 10.1	2 lb.	72.2	0.70	0.87	18.17	41.7
Dyrene	8, 10.1	1.6 oz.	65.9	1.43	2.67	48.63	28.0
Bayleton + Dyrene	8, 10.1	1 oz. + 1.67 lb.	75.9	0.63	0.90	24.06	34.0
Bayleton + Dithane M-45	8, 10.1	1 oz. + 2.0 lb.	79.4	0.47	0.87	3.13	38.7
Flsd.$_{10}$			10.7	N.S.	N.S.	N.S.	18.6

[a]The variety used was Pike. The plot was located in Tolono, Illinois.

Checklist of Insecticides

Many of the insecticides included in this checklist are listed in Circulars 897 (Commercial Vegetables), 898 (Livestock), 899 (Field Crops), 900 (Homeowner), 1073 (Fruit), and 1076 (Turfgrass). Those circulars contain the current Illinois insecticide recommendations. The following list, however, is only intended as a quick insecticide reference. In addition to the recommended insecticides, we have included some that have label approval but are not in the Illinois recommendations.

The checklist is structured in the following way. The insecticide names are listed at the left in capital letters. Usually these names are the common ones, but if they are trade names they are marked with an asterisk. Trade names and other indentifying names are given on the same line following the common names. The name of the basic manufacturer is listed at the right, after the trade name.

Toxicity ratings for each insecticide are listed below the name. An acute oral toxicity rating for each insecticide is given. A dermal toxicity rating is also given if known. Acute oral toxicity ratings are usually obtained by feeding white rats; acute dermal ratings are determined by skin absorption tests on rats or rabbits. These figures are expressed as LD_{50}. This term indicates the size of the dose that is lethal to 50 percent of the test animals. LD_{50} is expressed in terms of millograms of actual insecticide per kilogram of body weight of the test animal—mg/kg. Chronic oral toxicity (90 days plus) with the no-effect level in the diet is expressed in parts per million. When available, toxicity ratings of insecticides to fish, birds, and honeybees are also given. Those for bees can be interpreted readily as follows. (1) High—kills bees on contact and by residues; bees should be removed from area of application. (2) Moderate—kills bees if applied over them; limited damage with correct dosage, timing, and method of application. (3) Low—can be used around bees with few precautions and a minimum of injury.

To express toxicity in practical terms, the factor 0.003 times the LD_{50} value will give the ounces of actual insecticide required to be lethal to one of every two 187-pound men or other warm-blooded animals. As an example, the oral LD_{50} value for malathion is 1,200 mg/kg; thus, if a group of men each weighing 187 pounds ate 3.6 ounces (1,200 times 0.003) of actual malathion per man, half of them would succumb. The dermal-toxicity-LD_{50} value of malathion is approximately 4,000 mg/kg, or, for a 187-pound man, 12 ounces. If you check the list of insecticides, you will find some highly toxic chemicals with LD_{50} values from 1 to 10 mg/kg. For the average man, fatal doses of those chemicals would be in the range of 0.003 to 0.03 ounce.

By comparison, the oral LD_{50} value of aspirin is 1,200 mg/kg, or 3.6 ounces per 187-pound man, the equivalent of malathion. The oral LD_{50} value of ethyl alcohol is 4,500 mg/kg. If a group of 187-pound men each consumed somewhat more than 1 quart of 80 proof whiskey in 45 minutes, they would not only be intoxicated; 50 percent of them might die.

It is important to remember that these toxicity ratings are approximate and pertain to white rats and sometimes rabbits. Such ratings, however, do serve as a guide for comparing the toxicity of insecticides as well as an indication of their comparative acute toxicity to other warm-blooded animals and man. Acute toxicity ratings expressed as LD_{50} are classified as to their relative danger when being used. An acute oral LD_{50} of 500 mg/kg or higher is rated as low toxicity; an LD_{50} rating of 50 to 500 is moderate; and 50 or less is high.

After the toxicity ratings, the checklist shows the chemical group to which the insecticide belongs. You can thus determine which insecticides have similar chemical properties. A brief statement follows the chemical group name, describing in general terms the principal uses for the insecticide. If an insecticide is classified as a RESTRICTED USE INSECTICIDE, an applicator who purchases and uses it will need to be certified as a private or commercial applicator. See your county Extension adviser for more information, if necessary.

Remember, this is *not* a list of recommended insecticides, nor is it to be used in determining what insecticide to use to control a particular insect. This list is a quick insecticide reference to compare common chemical names with trade names and to determine their toxicity ratings and general uses.

NOTE: A "Restricted Use Insecticide" rating means that some or all uses, or some or all formulations, are classified for Restricted Use. For more specific information on "Restricted Use Insecticides," see the current year's issues of the University of Illinois circulars on insecticide recommendations.

INSECTICIDES

ABATE*—see temephos

ACARALATE*—see chloropropylate

ACEPHATE — Orthene — Chevron

Acute oral—361
Acute dermal—2,000

Bee toxicity—High
Fish toxicity—Low
Bird toxicity—Moderate

Organic phosphate—Labeled for use against certain insects on ornamentals, soybeans, and vegetables.

ALDICARB — UC 21149, Temik — Union Carbide

Acute oral—5 to 10 (10% G)
Acute dermal—1,400 (10% G)

Bee toxicity—High
Bird toxicity—Moderate

Carbamate—Residual, systemic insecticide and miticide for use against mites and certain insects of ornamentals and cotton. RESTRICTED USE INSECTICIDE.

*Trade name.

ALFA-TOX* CIBA-Geigy

Bee toxicity—High

A combination of methoxychlor and diazinon used as a spray for alfalfa weevil control.

ALLETHRIN Synthetic pyrethrin, Pynamin FMC, MGK, Stauffer, Sumitomo

Acute oral—680 to 1,000
Acute dermal—11,200
Chronic oral—5,000

Bee toxicity—Low

Synthetic derivative—Used in household aerosols and fly sprays as a quick knockdown.

ALTOSID—see methoprene

ALUMINUM PHOSPHIDE Phostoxin, Detia Hollywood Termite Company, Research Products Company

Acute vapor—2,000 ppm (fatal to man in short time)

Fumigant—Used on stored products. Highly toxic when phosphine gas is formed. <u>RESTRICTED USE INSECTICIDE</u>.

AMAZE*—see isofenphos

AMBUSH*—see permethrin

ARAMITE* U.S. Rubber

Acute oral—3,900
Chronic oral—500

Fish toxicity—Moderate
Bee toxicity—Low
Bird toxicity—Very low

Sulfonate—Miticide limited to ornamentals and household. No clearance on fruit or vegetables, has carcinogenic properties.

ASPON* Stauffer

Acute oral—1,224

Bird toxicity—Very low

Organic phosphate—For control of chinch bugs and sod webworms in turfgrass.

ATROBAN*—see permethrin

ATTAC*—see toxaphene

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*Trade name.

AZINPHOSMETHYL | Guthion | Mobay

Acute oral—11 to 13
Acute dermal—220
Chronic oral—5

Bee toxicity—High
Bird toxicity—Moderate

Organic phosphate—Used on cotton, forage crops, ornamental crops, vegetables, and tree fruit to control both insects and mites. RESTRICTED USE INSECTICIDE.

AZODRIN*—see monocrotophos

BACILLUS POPILLIAE | Doom

Bacterial—Nontoxic microbial insecticide. Applied to soil to infect Japanese beetle grubs with milky spore disease.

BACILLUS THURINGIENSIS | Thuricide, Dipel, Bactur, Bactimos, SOK-BT, Others | Abbott Lab, Sandoz-Wander, Thompson-Hayward, Upjohn, Biochem

Acute oral—>10,000
Chronic oral—>8,400
Acute dermal—>3,400

Fish toxicity—Extremely low
Bee toxicity—Extremely low
Bird toxicity—Extremely low

Bacterial—A nontoxic microbial insecticide used to control caterpillars on vegetable crops and ornamentals. Additional variety used to control mosquito larvae.

BACTIMOS*—see *Bacillus thuringiensis*

BACTUR*—see *Bacillus thuringiensis*

BAYGON*—see propoxur

BAYTEX*—see fenthion

BENDIOCARB | Tattoo, Ficam, Turcam, Rotate, NC 6897 | BFC

Acute oral—179
Acute dermal—1,000

Carbamate—Labeled for use on cockroaches and other household and turf insects; experimental-use permit for corn soil insects.

BENZYL BENZOATE | Monsanto

Acute oral—500 to 5,000
Repellent—A repellent for chiggers, mosquitoes, and ticks on man.

BIDRIN*—see dicrotophos

*Trade name.

BINAPACRYL　　Morocide, Acricid　　FMC

Acute oral—161
Acute dermal—1,350

Bee toxicity—Low

Nitrophenol—A miticide for certain fruit crops.

BUTOXY POLYPROPYLENE GLYCOL　　Craig Fly Repellent　　Union Carbide

Acute oral—9,100 to 11,200
Chronic oral—640

Repellent—Used in sprays for cattle against flies.

CARBARYL　　Sevin, Savit　　Union Carbide

Acute oral—500 to 850
Acute dermal—4,000+
Chronic oral—200

Fish toxicity—Very low
Bee toxicity—High
Bird toxicity—Very low

Carbamate—A general insecticide registered for control of many pests of field crops, vegetables, fruit, the household, and livestock.

CARBOFURAN　　Furadan　　FMC, Mobay

Acute oral—8 to 14
Acute dermal—>1,000

Bird toxicity—Moderate
Bee toxicity—High

Carbamate—Systemic insecticide for corn, soybeans and certain vegetable soil insects and use on alfalfa. RESTRICTED USE INSECTICIDE.

CARBON DISULFIDE　　Stauffer

Chronic vapor—20 ppm (40 hr.)
Acute vapor—200 ppm (1 hr.)

Fumigant—Used on stored products.

CARBON TETRACHLORIDE　　Allied, Diamond Shamrock, Dow, FMC, Frontier, Stauffer

Acute oral—5,730 to 9,770
Acute dermal—5,070 to 8,780
Chronic vapor—10 ppm (40 hr.)
Acute vapor—300 ppm (1 hr.)

Fumigant—Used as safener in fumigant mixtures for stored grain insects.

CARBOPHENOTHION　　Trithion　　Stauffer

Acute oral—10 to 30
Acute dermal—27 to 54
Chronic oral—5

Bee toxicity—Moderate

Organic phosphate—Insecticide with lasting residue with limited use on some fruit, vegetables and field crops. It is used chiefly as a miticide.

CHLORDANE Velsicol

Acute oral—335 to 430
Acute dermal—690 to 840
Chronic oral—25+

Fish toxicity—Very high
Bee toxicity—Moderate
Bird toxicity—Moderate

Chlorinated hydrocarbon—A residual soil insecticide for termites. Manufacture for crop use prohibited.

CHLORDIMEFORM Galecron, Fundal CIBA-Geigy, Nor-Am

Acute oral—162 to 170
Acute dermal—225
Chronic oral—250

Bee toxicity—Low
Bird toxicity—Low

Formandidine—Manufacture for agricultural use prohibited. RESTRICTED USE INSECTICIDE.

CHLOROPICRIN Picfume Dow, Morton

Chronic vapor—0.1 ppm (40 hr.)
Acute vapor—20 ppm (1 hr.)

Fumigant—Used on stored products in ship holds. RESTRICTED USE INSECTICIDE.

CHLOROPROPYLATE Acaralate CIBA-Geigy

Acute oral—34,600
Acute dermal—10,200
Chronic oral—40

Bee toxicity—Low

Chlorinated hydrocarbon—Miticide for fruit crops.

CHLORPYRIFOS Dursban, Lorsban Dow

Acute oral—97 to 276
Acute dermal—2,000

Bee toxicity—High
Bird toxicity—Moderate
Fish toxicity—Very high

Organic phosphate—Used as a soil insecticide in corn and some vegetable crops and for mosquito control. Used for roach control as well as for lawn insects. Labeled for peach, ash, and lilac borer control. Labeled for termite control.

CIODRIN*—see crotoxyphos

CIOVAP*—mixture of crotoxyphos and dichlorvos. Used as a spray on cattle for pasture flies.

CO-RAL*--see coumaphos

*Trade name.

COUMAPHOS | Co-Ral | Mobay

Acute oral—15 to 41
Acute dermal—860
Chronic oral—5

Bee toxicity—Moderate
Bird toxicity—Moderate

Organic phosphate—A systemic insecticide for beef cattle and poultry to control grubs, lice, and mites.

COUNTER*—see terbufos

CROTOXYPHOS | Ciodrin, SD 4294 | Diamond Shamrock

Acute oral—125
Acute dermal—385
Chronic oral—7

Bee toxicity—High

Organic phosphate—Used to control livestock insects, especially biting flies.

CRUFOMATE | Dowco 132, Ruelene | Dow

Acute oral—460 to 635
Acute dermal—2,000 to 4,000
Chronic oral—10 to 30

Organic phosphate—A systemic insecticide for controlling grubs and lice on beef cattle.

CYGON*--see dimethoate

CYTHION*—see malathion

DASANIT*—see fensulfothion

DBP*—see dibutyl phthalate

DDD*—see TDE

DDVP*—see dichlorvos

DEET | Off, Delphene, diethyltoluamide diethyl-meta-toluamide | BFC

Acute oral—1,950
Acute dermal—10,000

Repellent—Used for control of biting insects and chiggers on man. Applied directly to skin.

DE-FEND*—see dimethoate

DELNAV*—see dioxathion

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*Trade name.

DEMETON | Systox | Mobay

Acute oral—2 to 6
Acute dermal—8 to 14
Chronic oral—1

Fish toxicity—Moderate
Bee toxicity—Moderate
Bird toxicity—Moderate

Organic phosphate—A systemic miticide and aphicide for use in greenhouses and orchards and on certain field and vegetable crops. RESTRICTED USE INSECTICIDE.

DETIA*—see aluminum phosphide

DIAZINON | Spectracide, D·Z·N | CIBA-Geigy

Acute oral—76 to 108
Acute dermal—455 to 900
Chronic oral—1

Fish toxicity—High
Bee toxicity—High
Bird toxicity—High

Organic phosphate—A general insecticide; can be used as a residual fly spray in barns and for control of insect pests of turf, vegetables, fruit, field crops, and the household.

DIBROM*—see naled

DIBUTYL PHTHALATE | DBP | Allied, Monsanto

Acute oral—5,000 to 15,000

Bird toxicity—Very low

Repellent—For impregnating clothing to repel chiggers and mites.

DICHLORVOS | DDVP, Vapona | Diamond Shamrock

Acute oral—56 to 80
Acute dermal—75 to 107

Fish toxicity—Moderate
Bee toxicity—High
Bird toxicity—Moderate

Organic phosphate—Short-lived residual insecticide for livestock, fly bait, greenhouses, and warehouses. Also impregnated in plastic resin strips.

DICOFOL | Kelthane | Rohm and Haas

Acute oral—1,000 to 1,100
Acute dermal—1,000 to 1,230
Chronic oral—20

Fish toxicity—High
Bee toxicity—Low
Bird toxicity—Low

Chlorinated hydrocarbon—Miticide used on vegetables, fruit, and ornamentals.

DICROTOPHOS | Bidrin | Shell

Acute oral—22
Acute dermal—225
Chronic oral—1

Bee toxicity—High
Bird toxicity—High

Organic phosphate—A systemic insecticide used for mimosa webworm control on honey locust. Recommended in many states as an injected systemic for elm bark beetle control, but to be applied only by people especially trained to do the work. RESTRICTED USE INSECTICIDE.

*Trade name.

DIMETHOATE | Cygon, De-Fend | American Cyanamid

Acute oral—215
Acute dermal—400 to 610
Chronic oral—5

Fish toxicity—Very low
Bee toxicity—High
Bird toxicity—Moderate

Organic phosphate—A systemic insecticide for use on field, fruit, vegetable, and ornamental crops and as a residual fly spray inside of livestock barns.

DIMETHYL PHTHALATE | DMP | Monsanto, Allied

Acute oral—8,200
Acute dermal—4,000+

Repellent—General purpose mosquito repellent.

DINITRO COMPOUNDS | Elgetol 318, DNOC | Dow, FMC, Chem. Ins. Corp.

Acute oral—5 to 60
Acute dermal—150 to 600

Nitrophenol—Used primarily for controlling aphids, mites, and scale insects as dormant fruit spray.

DINOCAP | Karathane | Rohm and Haas

Acute oral—980 to 1,190
Acute dermal—4,700 to 9,400

Bee toxicity—Low

Dinitro—A fungicide used for control of powdery mildew; also acts as a mite suppressant.

DIOXATHION | Delnav | BFC

Acute oral—23 to 43
Acute dermal—63 to 235
Chronic oral—4

Bee toxicity—Low
Bird toxicity—Low

Organic phosphate—Miticide and insecticide used as an animal dip and spray. RESTRICTED USE INSECTICIDE.

DIPEL*—see *Bacillus thuringiensis*

DIPTEREX*—see trichlorfon

DISULFOTON | Di-Syston | Mobay

Acute oral—2 to 7
Acute dermal—6 to 15
Chronic oral—2

Bee toxicity—Moderate
Bird toxicity—Moderate

Organic phosphate—A systemic insecticide to control aphids, leafhoppers, and flea beetles on certain vegetable and field crops. RESTRICTED USE INSECTICIDE.

*Trade name.

DI-SYSTON*—see disulfoton

DMP*—see dimethyl phthalate

DNOC*—see dinitro compounds

DURSBAN*—see chlorpyrifos

DYFONATE*—see fonofos

DYLOX*—see trichlorfon

D·Z·N*—see diazinon

ECOPRO*—see temephos

ECTIBAN*—see permethrin

ECTRIN*—see fenvalerate

ENDOSULFAN — Thiodan, Tiovel — FMC

Acute oral—18 to 43
Acute dermal—74 to 130
Chronic oral—30

Bee toxicity—Moderate
Bird toxicity—Low

Chlorinated hydrocarbon—Used on some vegetable crops to control aphids; also controls peach borers.

ENDRIN — Shell, Velsicol

Acute oral—8 to 18
Acute dermal—15 to 18
Chronic oral—1

Fish toxicity—Very high
Bee toxicity—Moderate
Bird toxicity—High

Chlorinated hydrocarbon—Use not recommended in Illinois. <u>RESTRICTED USE INSECTICIDE</u>.

ENTEX*—see fenthion

EPN — DuPont

Acute oral—8 to 36
Acute dermal—25 to 230

Bee toxicity—High
Bird toxicity—Moderate

Organic phosphate—Used for insect control on field crops. <u>RESTRICTED USE INSECTICIDE</u>.

ETHION — FMC

Acute oral—27 to 65
Acute dermal—62 to 245
Chronic oral—3

Bee toxicity—Low
Bee toxicity—Very low

(continued)

*Trade name.

ETHION (continued)

Organic phosphate—Used for control of onion maggots and of aphids and mites in orchards. Used for insect control on corn, sorghum, turf and ornamentals and various fruit and vegetable crops.

ETHOPROP — Mocap — Rhone Polenc

Acute oral—62
Acute dermal—26

Bee toxicity—Moderate
Bird toxicity—Moderate

Organism phosphate—Residual chemical for control of soil insects and nematodes. RESTRICTED USE INSECTICIDE.

ETHYLENE DIBROMIDE — American Potash, Dow, FMC, Great Lakes, Michigan Chemical

Acute oral—117 to 146
Acute dermal—300
Chronic vapor—25 ppm (40 hr.)
Acute vapor—200 ppm (1 hr.)

Fumigant—Used on stored products.

ETHYLENE DICHLORIDE — Diamond Shamrock, Dow, Olin Mathieson

Acute oral—770
Acute dermal—3,890
Chronic vapor—50 ppm (40 hr.)
Acute vapor—1,000 ppm (1 hr.)

Fumigant—Used on stored grains.

EUGENOL — Penick

Acute oral—500 to 5,000

Attractant—Used for attacking fruit flies.

Famphos*—see famphur

FAMPHUR — Famphos, Warbex — American Cyanamid

Acute oral—35 to 62
Acute dermal—1,460 to 5,093
Chronic oral—1

Bee toxicity—High
Bird toxicity—High

Organic phosphate—A systemic insecticide used for controlling grubs in cattle.

FENSULFOTHION — Dasanit — Mobay

Acute oral—2 to 11
Acute dermal—3 to 30

Bee toxicity—High
Bird toxicity—High

Organic phosphate—Insecticide and nematicide for soil insect control in corn and for onion maggot control. RESTRICTED USE INSECTICIDE.

*Trade name.

FENTHION Baytex, Entex, Tiguvon Mobay

Acute oral—215 to 245
Acute dermal—330
Chronic oral—2

Fish toxicity—Low
Bee toxicity—High
Bird toxicity—High

Organic phosphate—Residual fly spray for livestock barns. Used in mosquito control and for household insects.

FENVALERATE Pydrin, Ectrin Diamond Shamrock, Shell

Acute oral—450
Acute dermal—>1,000

Fish toxicity—High
Bee toxicity—High
Bird toxicity—Low

Synthetic pyrethrin—Labeled for use on potatoes. Used on some field and vegetable crops. State and federal labels for fly control on livestock.

FICAM*—see bendiocarb

FONOFOS N2790, Dyfonate Stauffer

Acute oral—16
Acute dermal—319

Bird toxicity—Moderate

Organic phosphate—Used for soil insect control on corn and vegetable crops. RESTRICTED USE INSECTICIDE.

FUNDAL*—see chlordimeform

FURADAN*—see carbofuran

GALECRON*—see chlordimeform

GARDONA*—see stirofos

GERANIOL Fritche

Attractant—Used as an attractant in traps for Japanese beetle.

GUTHION*--see azinphosmethyl

GYPLURE USDA

Attractant—Used as an attractant for gypsy moths.

HYDROCYANIC ACID HCN

Acute oral—4
Chronic vapor—10 ppm (40 hr.)
Acute vapor—40 ppm (1 hr.)

Fumigant—Used on stored products, for rodent control and building fumigation. RESTRICTED USE INSECTICIDE.

*Trade name.

IMIDAN*—see phosmet

ISOFENPHOS — Amaze, Oftanol, Bay SRA-12869 — Mobay

Acute oral—38
Acute dermal—188

Organic phosphate—Corn soil insecticide and labeled for grub control in turf. RESTRICTED USE INSECTICIDE.

KARATHANE*—see dinocap

KELTHANE*—see dicofol

KORLAN*—see ronnel

LANNATE*—see methomyl

LEAD ARSENATE

Acute oral—1,050 — Bee toxicity—High
Acute dermal—2,400+ — Bird toxicity—Low

Arsenical—Used to control certain chewing insects of fruit and ornamentals.

LETHANE 60* — Rohm and Haas

Acute oral—250 to 500
Acute dermal—3,000

Thiocyanate—Used in household insecticide sprays.

LETHANE 384*

Acute oral—90
Acute dermal—250 to 500

Thiocyanate—Used in livestock fly sprays as a quick knockdown agent.

LINDANE — gamma BHC — Hooker

Acute oral—88 to 91 — Fish toxicity—Very high
Acute dermal—900 to 1,000 — Bee toxicity—High
Chronic oral—50 — Bird toxicity—Moderate

Chlorinated hydrocarbon—Used to control spittlebugs on certain crops and mite and louse control on certain livestock.

LORSBAN*—see chlorpyrifos

*Trade name.

MALATHION — Cythion — American Cyanamid

Acute oral—1,000 to 1,375
Acute dermal—4,444+
Chronic oral—100 to 1,000

Fish toxicity—Moderate
Bee toxicity—High
Bird toxicity—Low

Organic phosphate—General use insecticide for control of household insects, certain livestock insects, and certain crop insects. Premium grade used for treating grain to be stored.

MARLATE*—see methopychlor

MESUROL*—see methiocarb

METALDEHYDE

Acute oral—1,000

Attractant—Used in combination with stomach poisons for snail and slug baits.

META SYSTOX-R*—see oxdemetonmethyl

METHAMIDOPHOS — Monitor, Ortho 9006 — Chevron, Mobay

Acute oral—18 to 21
Acute dermal—118

Bee toxicity—High

Organic phosphate—Labeled for use on cole crops, potatoes, and cotton. RESTRICTED USE INSECTICIDE.

METHIDATHION — Supracide — CIBA-Geigy

Acute oral—25 to 65
Acute dermal—375 to 640

Fish toxicity—High
Bee toxicity—High
Bird toxicity—Moderate

Organic phosphate—For weevils, aphids, spittlebugs, and leafhoppers in alfalfa. Also mites on sorghum. RESTRICTED USE INSECTICIDE.

METHIOCARB — Mesurol — Mobay

Acute oral—130 to 135
Acute dermal—200

Bee toxicity—High
Bird toxicity—Low

Carbamate—Prepared as a bait for snail and slug control in nonfood crop areas. Labeled for insect control on peach and cherry. Is a bird repellent. RESTRICTED USE INSECTICIDE.

*Trade name.

METHOMYL | 1179, Lannate, Nudrin | DuPont, Shell

Acute oral—17 to 24
Acute dermal—1,500
Chronic oral—100

Bee toxicity—High
Bird toxicity—Low

Carbamate—Used for worm control on cabbage, tomatoes, sweet corn, and field corn and soybeans. RESTRICTED USE INSECTICIDE.

METHOPRENE | Altosid | Zoecon

Acute oral—734,600

Fish toxicity—Very low
Bird toxicity—Very low

Insect Growth Regulator—Larvicide for floodwater mosquitoes and as a feed-through for beef cattle for horn flies.

METHOXYCHLOR | Marlate | DuPont, CIBA-Geigy

Acute oral—5,000
Acute dermal—6,000+
Chronic oral—100

Fish toxicity—Very high
Bee toxicity—Low
Bird toxicity—Very low

Chlorinated hydrocarbon—Used in many homeowner fruit and vegetable sprays or dust mixtures, for certain field crop insects, and for Dutch elm disease control.

METHYL BROMIDE | American Potash, Dow, Frontier, Great Lakes, Michigan Chemical

Chronic vapor—20 ppm (40 hr.)
Acute vapor—200 ppm (1 hr.)

Fumigant—Used on stored products. RESTRICTED USE INSECTICIDE.

METHYL PARATHION | Penncap-M | American Potash, Monsanto, Shell, Stauffer, Pennwalt

Acute oral—14 to 24
Acute dermal—67

Fish toxicity—Very low
Bee toxicity—High
Bird toxicity—Moderate

Encapsulated

Acute oral—270 to 480
Acute dermal—5,400

Organic phosphate—It is closely related to parathion and is used primarily for insect control on cotton. Used for insect control on field crops. RESTRICTED USE INSECTICIDE.

METHYL TRITHION* Stauffer

Acute oral—98 to 120
Acute dermal—190 to 215

Bee toxicity—High
Bird toxicity—Low

Organic phosphate—It is closely related to trithion or carbophenothion. It is a residual insecticide used in both insect and mite control on certain fruits and vegetables.

MEVINPHOS Phosdrin Shell

Acute oral—4 to 6
Acute dermal—4 to 5
Chronic oral—0.8

Organic phosphate—A short-lived residual insecticide for control of insects on certain field and vegetable crops. RESTRICTED USE INSECTICIDE.

MGK-R11* MGK

Acute oral—2,500
Acute dermal—2,000+

Repellent—Used in sprays for cattle against flies.

MGK-R326* MGK

Acute oral—5,230 to 7,230
Acute dermal—9,400

Repellent—Used in sprays for cattle against flies.

MOCAP*—see ethoprop

MONITOR*—see methomide

MONOCROTOPHOS Azodrin, SD 9129 Shell

Acute oral—21
Acute dermal—354
Chronic oral—1

Bee toxicity—High
Bird toxicity—High

Organic phosphate—A systemic insecticide for use on cotton and fruit crops upon label approval. RESTRICTED USE INSECTICIDE.

MORESTAN*—see oxythroquinox

MOROCIDE*—see binapacryl

*Trade name.

NALED | Dibrom | Chevron

Acute oral—250
Acute dermal—800

Fish toxicity—High
Bee toxicity—High
Bird toxicity—Low

Organic phosphate—A short-lived residual insecticide for use in greenhouses and for certain field crops. Also used in fly baits in livestock barns.

NEGUVON*—see trichlorfon

NICOTINE | Nicotine Sulfate | Center Chemical, Inc.

Acute oral—83
Acute dermal—285

Bee toxicity—Low

Heterocyclic botanical compound—Contact insecticide that is used to control aphids in greenhouses. RESTRICTED USE INSECTICIDE.

NUDRIN*—see methomyl

OFTANOL*—see isofenphos

OMITE | Uniroyal

Acute oral—2,200

Bee toxicity—Low

Sulfite—Miticide for use on fruit crops. Not harmful to predatory mites.

ORTHENE*—see acephate

OXAMYL | DPX 1410, Vydate | DuPont

Acute oral—5 to 6
Acute dermal—700 to 800

Carbamate—Nematicide labeled for use on tobacco, nursery stock, and nonbearing fruit trees. Also has state label or experimental use permit in some states for certain vegetables.

OXYDEMETONMETHYL | Metasystox-R | Mobay

Acute oral—65 to 75
Acute dermal—250
Chronic oral—10

Bee toxicity—Moderate
Bird toxicity—Moderate

Organic phosphate—A systemic insecticide for controlling aphids, mites, and other insects on vegetable crops, field crops, and ornamentals.

*Trade name.

OXYTHROQUINOX | Morestan | Mobay

Acute oral—1,100 to 1,800
Acute dermal—2,000+
Chronic oral—50

Bee toxicity—Low

Organic carbamate—A miticide to be used on apples prior to bloom.

PARADICHLOROBENZENE | PDB | Monsanto

Acute oral—1,000+

Fumigant—Used as fumigant to control fabric pests.

PARATHION | American Potash, Monsanto, Shell, Stauffer, Velsiocol

Acute oral—4 to 13
Acute dermal—7 to 21
Chronic oral—1

Fish toxicity—High
Bee toxicity—High
Bird toxicity—Moderate

Organic phosphate—A highly toxic insecticide to control a wide range of insects and mites on vegetables, fruit, and field crops. RESTRICTED USE INSECTICIDE.

PENNCAP-M*—see methyl parathion

PENTAC* | HRS-16 | Hooker

Acute oral—3,160
Acute dermal—3,160+

Bee toxicity—Low

Chlorinated hydrocarbon—Residual miticide used on greenhouse floral crops and nursery stock.

PERMETHRIN | Ambush, Pounce, SBP-1513, Ectiban, Atroban, Pramex | Burroughs Welcome, FMC, ICI, Penick

Acute oral—4,000
Acute dermal—4,000

Fish toxicity—Very high
Bee toxicity—High
Bird toxicity—Low

Synthetic pyrethrin—State labels for residual barn spray (Atroban), greenhouse chrysanthemum leaf miner control (Pramex) and emergency label for canning pumpkins (Ambush, Pounce). Federally registered for use as a foliar spray against certain insects affecting soybeans.

PERTHANE* | Rohm and Haas

Acute oral—4,000+
Chronic oral—500

Fish toxicity—Very high
Bee toxicity—Moderate
Bird toxicity—Very low

Chlorinated hydrocarbon—Used in formulating household insecticides.

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*Trade name.

PHORATE | Thimet | American Cyanamid

Acute oral—1 to 3
Acute dermal—3 to 6

Bee toxicity—Moderate
Bird toxicity—Moderate

Organic phosphate—A systemic insecticide for use on certain vegetable and field crops and as a soil insecticide for corn.

PHOSALONE | Zolone | Rhodia

Acute oral—120

Bee toxicity—Moderate

Organic phosphate—Used as a miticide and insecticide on fruit trees.

PHOSDRIN*—see mevinphos

PHOSMET | R-1504, Prolate, Imidan | Stauffer

Acute oral—147 to 216
Acute dermal—3,160

Bee toxicity—High
Bird toxicity—Low

Organic phosphate—Insecticide for fruit and ornamental insect control, corn and alfalfa insects, and cattle grubs.

PHOSPHAMIDON | Dimecron | Chevron

Acute oral—24
Acute dermal—107 to 143

Fish toxicity—Very low
Bee toxicity—High
Bird toxicity—High

Organic phosphate—A systemic insecticide for use on certain fruit and vegetable crops. RESTRICTED USE INSECTICIDE.

PHOSTOXIN*—see aluminum phosphide

PIPERONYL BUTOXIDE | FMC

Acute oral—7,500+
Acute dermal—1,880
Chronic oral—1,000

Synergist—Commonly used with pyrethrin.

PLICTRAN | Dow

Acute oral—1,675

Bee toxicity—Low

Tin—Miticide for use on fruit and greenhouse crops. Not harmful to predatory mites.

POUNCE*—see permethrin

PRAMEX*—see permethrin

*Trade name.

PROLATE—see Imidan

PROPOXUR Baygon Mobay

Acute oral—95 to 104
Acute dermal—1,000+
Chronic oral—800

Bee toxicity—High
Bird toxicity—Low

Carbamate—For use against mosquitoes, household insects, and certain lawn insects.

PROXOL*—see trichlorfon

PYDRIN*—see fenvalerate

PYRETHRUM pyrethrin I and II FMC, Penick, MGK

Acute oral—820 to 1,870
Acute dermal—1,880+
Chronic oral—1,000

Fish toxicity—High
Bee toxicity—Low
Bird toxicity—Very low

Botanical—Used as a fly control insecticide in household and livestock sprays.

RABON*—see stirofos

RAVAP*—mixture of dichlorvos and stirofos. Used as a residual wall spray for flies in livestock barns.

RESMETHRIN SBP-1382 Penick

Acute oral—3,500
Acute dermal—3,040

Bee toxicity—High
Bird toxicity—Very low

Synthetic pyrethrin—Used for flying and nuisance insects and whitefly control.

RONNEL Korlan, Trolene, Viozene Dow

Acute oral—1,250 to 2,630
Acute dermal—5,000+
Chronic oral—10

Bee toxicity—Moderate

Organic phosphate—Used in baits and sprays for fly control in livestock barns.

ROTATE*—see bendiocarb

ROTENONE derris, cube FMC, Penick

Acute oral—50 to 75
Acute dermal—940+
Chronic oral—25

Fish toxicity—Very high
Bee toxicity—Low
Bird toxicity—Low

Botanical—A contact poison used to control certain home garden insects and cattle grubs.

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*Trade name.

RUELENE*—see crufomate

SAVIT*—see carbaryl

SEVIN*—see carbaryl

SOK-BT*—see *Bacillus Thuringiensis*

SPECTRACIDE*—see diazinon

STIROFOS	Rabon, Gardona	Diamond Shamrock

Acute oral—4,000 to 5,000
Acute dermal—5,000+

Bee toxicity—High
Bird toxicity—Very low

Organic phosphate—used for control of livestock flies and external parasites of livestock; also, for worms attacking sweet corn.

SULFOXIDE — Penick

Acute oral—2,000
Acute dermal—9,000+
Chronic oral—2,000

Synergist—Commonly used with pyrethrin.

SUPRACIDE*—see methidathion

SYSTOX*—see demeton

TATTOO*—see bendiocarb

TEDION*—see tetradifon

TEMEPHOS	Abate, Ecopro	American Cyanamid

Acute oral—1,000 to 3,000
Acute dermal—1,024 to 1,782
Chronic oral—2

Bee toxicity—Moderate
Bird toxicity—Moderate

Organic phosphate—Used as a larvicide for mosquito control.

TEMIK*—see aldicarb

TERBUFOS	Counter	American Cyanamid

Acute oral—4 to 9
Acute dermal—25

Bird toxicity—High
Fish toxicity—High

Organic phosphate—A soil insecticide for the control of corn soil insects.

*Trade name.

TETRADIFON | Tedion | FMC, Phillips

Acute oral—14,700+
Acute dermal—10,000+

Bee toxicity—Low
Bird toxicity—Very low

Sulfonate—A miticide for fruit crops.

THANITE* | BFC

Acute oral—1,600
Acute dermal—6,000

Thiocyanate—Added to household and livestock sprays to increase knockdown of flying insects.

THIMET*—see phorate

THIODAN*—see endosulfan

THURICIDE*—see *Bacillus thuringiensis*

TIOVEL*—see endosulfan

TOXAPHENE | Attac | BFC

Acute oral—80 to 90
Acute dermal—780 to 1,075
Chronic oral—10

Fish toxicity—Very high
Bee toxicity—Low
Bird toxicity—Low

Chlorinated hydrocarbon—Used to control many insects of grain and forage crops, livestock, and vegetable and fruit crops. Used in backrubbers and as a sheep dip.

TRICHLORFON | Dylox, Dipterex, Neguvon, Proxol | Mobay, Upjohn

Acute oral—560 to 630
Acute dermal—2,000+

Fish toxicity—Very low
Bee toxicity—Low
Bird toxicity—Low

Organic phosphate—Dipterex is used in fly baits, and Dylox is used as a spray for certain field crop, vegetable, and ornamental insects. Used for grub and caterpillar control in turfgrass.

TRITHION*—see carbophenothion

TURCAM*—see bendiocarb

VAPONA*—see dichlorvos

VENDEX* | Shell

Acute oral—>2,000
Acute dermal—>2,000

Miticide for use on ornamentals, apples, and pears.

*Trade name.

VYDATE*—see oxamyl

WARBEX*—see famphur

ZOLONE*—see phosalone

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*Trade name.

Prepared by entomologists of the Illinois Agricultural Extension Service and Illinois Natural History Survey. For additional copies, see your county Extension adviser.

1983 Insect Pest Management Guide

COMMERCIAL VEGETABLE CROPS AND GREENHOUSE VEGETABLES

Restricted-use insecticides are identified with an asterisk (*).
You must be certified as a pesticide applicator to use restricted-use pesticides.
See your county Extension adviser in agriculture for information.

Commercial vegetable gardeners find it impossible to produce vegetables profitably unless they control insects at maximum efficiency and minimum cost. The housewife of today will not accept unsightly wormy vegetables; not only are wormy fruits and vegetables unappetizing but the waste from trimming increases food costs. Thus the commercial vegetable gardener must produce a quality product that is acceptable and safe to the consumer. Careful use of the right insecticides will enable him to do this.

Insect pest-management programs, which include the wise selection of cultural, mechanical, biological, and chemical methods, are suggested for the major insect pests of vegetable crops. Insecticides, though, are still the most efficient means of managing most insects.

This suggested insecticide guide has been prepared for use by Illinois commercial vegetable farmers; it is not for home gardeners, who should use only those insecticides that are extremely safe to handle, apply, and store. Furthermore, the commercial vegetable gardener must use a wider variety of insecticides than the home gardener in order to obtain maximum insect control at the least cost.

In using insecticides, read the label and carefully follow the instructions. Do not exceed maximum rates suggested; observe carefully the interval between application and harvest, and apply only to crops for which use has been approved. Make a record of the product used, the trade name, the percentage content of the insecticide, the dilution, the rate of application per acre, and the dates of application.

Some of the insecticides suggested here can be poisonous to the applicator. In using them, the commercial grower is expected to use precautions to protect himself, his workers, and his family from undue or needless exposure.

In using this guide, always refer to the table on the next page, which lists the limitations and restrictions on use. These limitations apply to the vegetables as human food. If you use any portion of a vegetable for livestock food (tops, stalks, etc.), refer to the label for instructions as to the interval required between application and feeding.

The chemical names used in these tables may be unfamiliar to you. These names are the common coined chemical names and as such are not capitalized. Trade names are capitalized. In the table of limitations the common names are listed first. If the trade name is more commonly used, it is listed in parentheses following the common name. Throughout the tables of suggestions, however, the common name is used if there is one. In case you have a question, refer to the table of limitations.

These suggestions are subject to change without notification during the growing season.

Requested label clearances for a few uses of insecticides, carriers, and solvents are uncertain for 1983, since many requests have not been officially cleared. Anticipating needed changes in labeling, we began modifying these suggested uses a few years ago.

Check with your county Extension adviser if you are in doubt about the insecticide you plan to use. We will make announcements of label changes through newsletters and the news media to keep you up to date.

Insecticides are being classified for *general use* or *restricted use* by the U.S. Environmental Protection Agency. A person wishing to use an insecticide classified for restricted use must be certified as a private or commercial pesticide applicator by the Illinois Department of Agriculture. Contact your county Extension adviser in agriculture for details on this program.

A few insecticides have been classified at this time. More will be classified later.

Suggestions for the effective use of insecticides from a practical standpoint are based on available data. Soil textures, pH of the soil, rainfall, slope of the field, wind velocity at planting, method and accuracy of application, and other unpredictable factors affect efficiency.

This publication was prepared by entomologists of the University of Illinois College of Agriculture and the Illinois Natural History Survey.

Circular 897

LIMITATIONS FOR FIELD VEGETABLES IN DAYS BETWEEN APPLICATION AND HARVEST AND OTHER RESTRICTIONS ON USE OF INSECTICIDES IN ILLINOIS

(Blank spaces indicate that the material is not suggested for the specific use in Illinois)

Insecticide	Beans	Peas	Broccoli	Brussels sprouts	Cabbage	Cauliflower	Horse-radish	Radish	Turnip	Onions	Eggplant	Peppers	Tomatoes
acephate (Orthene)	14	...	..	..	..	..	..	..	....	....	..	7	..
*azinphosmethyl (Guthion)[2]	..	...	15	7	21	15	..	..	....	....	..	..	..
Bacillus thuringiensis[3]	..	...	0	0	0	0	..	..	....	....	..	..	0
carbaryl (Sevin)	0	...	3	3	3	3	3	3	3, 14A	....	0	0	0
carbofuran (Furadan)	..	...	..	..	..	..	..	..	....	....	..	21B	..
chlorpyrifos (Lorsban)	..	...	C	C	C	C	..	C	....	....	..	..	..
Dasanit	..	...	..	..	..	..	..	..	....	C, D	..	..	..
*demeton (Systox)	..	...	..	..	..	..	..	..	....	....	..	3	..
diazinon	..	...	5	..	7	5	..	10	10	10	..	..	1
dicofol (Kelthane)	7E	...	..	..	..	..	..	..	....	....	2	2	2
dimethoate (Cygon)	0E	0E	7	..	3	7	..	..	14	....	..	0	7
Dyfonate	..	...	C	..	C	C	..	..	....	C, D	..	..	..
ethion	..	...	..	..	..	..	..	..	....	C	..	..	..
fenvalerate (Pydrin)	..	...	3	..	3	3	..	..	....	....	..	..	7K
malathion	1	...	3	7	7	7	7	7	3	3	3	3	1
*methomyl (Lannate)	1	1, 5A	3	3	1	3	..	..	....	....	..	10	2
*mevinphos (Phosdrin)[2]	..	...	1	3	1	3	..	..	3	....	..	..	..
Monitor	..	...	21	21	35	28	..	..	....	....	..	..	..
naled (Dibrom)	..	...	1	1	1	1	..	..	4	....	..	..	..
oxydemetonmethyl (Meta-Systox R)	..	...	..	..	..	..	..	..	....	....	7F	0B	..
*parathion[2]	7	...	7	7	10	7	..	15	10	....	15	15	10
phorate (Thimet)[2]	C	...	..	..	..	..	..	..	....	....	..	..	..
rotenone	..	...	..	..	..	..	..	..	....	....	1	1	1
trichlorfon (Dylox)	..	...	..	21	21	21	..	..	28E	....	..	21	21

Insecticide	Potatoes	Collards	Kale	Lettuce	Spinach	Swiss chard	Sweet corn	Cucumbers[1]	Melons[1]	Pumpkins[1]	Squash[1] Winter	Squash[1] Summer
Bacillus thuringiensis[3]	..	0	0	0	0	..	..	..	..	..	..	..
carbaryl (Sevin)	0	14	14	14	14	14	0	0	0	0	0	0
carbofuran (Furadan)	14H	..	..	..	..	..	7L, 21A	..	..	..	..	..
chlorpyrifos (Lorsban)	..	..	..	..	..	..	50A, J	..	..	..	..	..
diazinon	..	10	10	10	10	12	C	7	3	..	3	7
dicofol (Kelthane)	..	..	..	..	..	..	..	2	2	2	2	2
dimethoate (Cygon)	0	14	14	14	14	14	..	..	3	..	..	..
Dyfonate	..	..	..	..	..	..	C	..	..	..	..	..
fenvalerate (Pydrin)	7E	..	..	..	..	..	1K	..	3	3	3	3
isofenphos (Amaze)	..	..	..	..	..	..	I	..	..	..	..	..
malathion	0	7	7	14	7	7	5	1	1	3	1	1
*methomyl (Lannate)	6	..	..	10	7	..	0, 3A	3	3	..	..	3
*mevinphos (Phosdrin)[2]	..	3	3	2	4	..	..	..	..	..	..	..
Mocap	..	..	..	..	..	..	C	..	..	..	..	..
naled (Dibrom)	..	4	4	1	1	1	..	..	..	..	..	..
*parathion[2]	5	10	10	21	14	21	12	15	7	10	15	15
phorate (Thimet)[2]	C	..	..	..	..	..	C	..	..	..	..	..
rotenone	..	1	1	1	1	1	..	..	..	..	..	..
terbufos (Counter)	..	..	..	..	..	..	C	..	..	..	..	..
trichlorfon (Dylox)	..	28G	21	28G	..	..	..	..	..	3F	..	..

* Use restricted to certified applicators only.

[1] Apply insecticides late in the day after the blossoms have closed to reduce bee kill.
[2] For use only by professional applicators or commercial gardeners.
[3] The trade names are Bactur, Dipel, Thuricide, and Sok Bt.

A. If tops or stover are to be used for feed.
B. Not more than twice per season.
C. Soil applications at planting time only.
D. Do not use on green onion crop.
E. Do not use tops for feed or food.
F. Not more than 3 times per season.
G. Not after edible portions or heads begin to form.
H. Not more than 8 times per season.
I. Crops other than corn and soybeans may be planted 10 months after application.
J. Not more than once per season.
K. Do not exceed 2 lb. a.i. per acre.
L. Not more than 4 applications per season.

REENTRY INTERVALS FOR WORKER PROTECTION

Insecticide	Hours
azinphosmethyl (Guthion)	24
demeton (Systox)	48
ethion	24
parathion	48

Workers must wear protective clothing if they enter treated fields before the time intervals shown at the right. They must also wear protective clothing for all other insecticides applied if the spray has not dried or the dust has not settled.

CABBAGE AND RELATED COLE CROPS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Cabbage maggots[1] (NHE-44)	All season	diazinon Dyfonate	3 2	Broadcast	Disk in just before planting. Use only for cabbage, cauliflower, and broccoli.
		diazinon granules	1	Furrow	At time of planting; on turnips a drenching spray of 1 lb. diazinon should be applied 30 days following treatment.
		*azinphosmethyl	3 oz. W.P. or 2 oz. E.C. per 50 gal. transplant water		6 fluid oz. transplant water per plant.
		diazinon	4 oz. per 50 gal. transplant water		
		Lorsban	3 oz. 4E per 1,000 ft. of row		Transplant drench to cabbage, broccoli, and cauliflower.
		Lorsban	1 oz. 4E per 1,000 ft. of row	Furrow	Radishes only.
Aphids (NHE-47) Thrips (NHE-48)	All season	*azinphosmethyl dimethoate malathion *mevinphos *parathion	¾ 0.3 1 ¼ 0.4	Foliage	When aphids appear, but before leaves begin to curl.
Cabbage loopers (NHE-45); diamond-back moth larvae; imported cabbage worms	All season	*Bacillus thuringiensis* fenvalerate *methomyl *Monitor	See rates on label 0.1-0.2 0.45-0.9 1	Foliage	When small worms first appear, and about every 5 to 7 days thereafter. Thorough spray coverage of foliage is important.
Cutworms	At planting	fenvalerate trichlorfon	0.1-0.2 1	Base of plants	As needed.
Flea beetles and leafhoppers	All season	carbaryl fenvalerate	1½ 0.1-0.2	Foliage	As needed.

E.C. = emulsion concentrate; W.P. = wettable powder.

* Use restricted to certified applicators only. [1] Maggots are resistant to diazinon in some areas of Illinois.

COLLARDS, KALE, LETTUCE, SPINACH, SWISS CHARD

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Aphids (NHE-47)	All season	diazinon dimethoate *mevinphos naled *parathion	½ 0.3 ¼ 1 0.4	Foliage	As needed.
Cutworms	On seedling plants	trichlorfon[1]	1	Base of plant and soil	When first damage appears.
Leafhoppers	All season	carbaryl dimethoate malathion	1½ 0.3 1	Foliage	When first leafhoppers appear, and as needed.
Caterpillars (NHE-45)	All season	*Bacillus thuringiensis* *methomyl[2] naled	See rates on label 0.45 1	Foliage	When small worms first appear and every 5 to 7 days thereafter.
Leaf miners	All season	diazinon dimethoate *parathion	½ 0.3 0.4	Foliage	When first miners are observed.
Flea beetles	All season	carbaryl rotenone	1 ¼	Foliage	As needed.

* Use restricted to certified applicators only.

[1] Do not use on spinach or Swiss chard.
[2] Use limited to lettuce and spinach only.

BEANS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Seed maggots (NHE-27)	All season	diazinon 50% W.P.[1] 3/5 oz./bu. Lorsban 25% W.P.[1] 2 oz./bu.		Seed Seed	Treat seed no longer than 3 months before planting.
		phorate granules	1½	Soilband	Place on either or both sides of row at planting but not in contact with seed.
Bean leaf beetles (NHE-67)	Early and late season	carbaryl malathion	1 1	Foliage	When feeding first appears and weekly for 2 or 3 applications as needed.
Leafhoppers (NHE-22) and plant bugs (NHE-68)	All season	carbaryl dimethoate malathion *methomyl	1 0.3 1 0.45	Foliage	Before plants become yellow and stunted. Repeat applications at weekly intervals as necessary.
		phorate granules	1½	Soilband	As for seed maggot.
Mexican bean beetles	Midseason and late season	carbaryl malathion	½ 1	Foliage	When occasional leaves show lacework feeding.
		phorate granules	1½	Soilband	As for seed maggot.
Aphids (NHE-47)	All season	dimethoate malathion	0.3 1	Foliage	Usually applied when a few aphids can be found on each plant, but before leaves begin to curl and deform.
		phorate granules	1½	Soilband	As for seed maggot.
Blister beetles (NHE-72)	Midseason and late season	carbaryl	1½	Foliage	As needed.
Corn earworms (NHE-33) Corn borers	Late season	acephate carbaryl *methomyl *parathion	⅜ 1½ 0.45 ½	Foliage	As needed, but usually after August 20. Worms may be present before bloom.
Mites	Midseason and late season	dicofol dimethoate malathion	0.4 0.3 1	Foliage	As needed, but especially during drouthy periods particularly if carbaryl has been used on crops.
		phorate granules	1½	Soilband	As for seed maggot.

* Use restricted to certified applicators only. [1] No restrictions when used as recommended.

CUCUMBERS AND OTHER VINE CROPS[1]

Insect	Time of attack	Insecticide[2]	Pounds of active ingredient per acre	Placement	Timing of application[1]
Striped and spotted cucumber beetles (NHE-46)	Seedling to mature plants	carbaryl carbofuran *parathion	1 2 ½	Foliage Soil Foliage	When beetles first appear; as often as necessary thereafter.
Aphids (NHE-47)	All season	diazinon dimethoate[2] malathion *parathion	½ 0.3 1 ½	Foliage	When aphids become noticeable.
Squash bugs (NHE-51)	All season	fenvalerate *parathion trichlorfon[3]	0.2 ½ 1	Foliage	Do not apply until first eggs are found hatching (about June 15 to July 15); controls only nymphs.
Leafhoppers	July-August	fenvalerate malathion dimethoate[2]	0.1-0.2 1 0.3	Foliage	As needed.
Squash vine borers	June-September	carbaryl fenvalerate	1 0.1-0.2	Base of stem for 3 ft.	Weekly applications when vines begin to run—usually 5 applications.
Pickle worms	August-September	carbaryl fenvalerate	1 0.1-0.2	Foliage	Weekly applications, beginning in late August.
Mites	July-September	dicofol malathion *parathion	½ 1 ½	Foliage	As needed.
Cutworms (NHE-77)	April-June	carbaryl fenvalerate	2 0.2	Base of plants	As needed.

* Use restricted to certified applicators only.
[1] Spray vine crops with insecticide only late in the day after blossoms have closed to reduce bee kill. [2] Do not use dimethoate on cucumbers.
[3] Pumpkin is the only vine crop for which trichlorfon can be used for squash bug control.

TOMATOES AND EGGPLANT

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Cutworms (NHE-77)	Early and midseason	carbaryl trichlorfon	2 1	Base of plants or foliage	As needed.
Flea beetles	May-June	carbaryl rotenone	2 0.2-0.4	Foliage	Apply every week as long as needed.
Aphids (NHE-47)	May-July	diazinon dimethoate[1] malathion *parathion	½ 0.3 1 0.4	Foliage	As needed, but before leaves curl.
Cabbage loopers	July-September	*Bacillus thuringiensis* fenvalerate *methomyl	See rates on label 0.1-0.2 0.45-0.9	Foliage	When loopers are present.
Corn earworms Corn borers Hornworms	July-September	carbaryl fenvalerate *methomyl[1]	2 0.1-0.2 0.45-0.9	Foliage	Add to weekly applications of fungicide sprays beginning at first fruit set when first small worms appear.
Mites	July-September	carbophenothion dicofol malathion *parathion	1 ½ 1 0.4	Foliage	As needed.
Russet mites	July-September	*parathion sulfur dust[2] sulfur spray[2]	0.4 10 10	Foliage	As needed.
Blister beetles (NHE-72)	June-September	carbaryl *parathion	1½ ¼	Foliage	As needed.
Fruit flies and picnic beetles	August-October	carbaryl diazinon	2 ½	Foliage	When flies or beetles first appear.

* Use restricted to certified applicators only. [1] Use cleared only on tomatoes. [2] No limitations on use.

PEPPERS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Aphids (NHE-47)	May-July	dimethoate demeton *methomyl oxydemetonmethyl acephate	0.3 ⅜ 0.45 ½ ½	Foliage	Only when aphids are present. Add to borer spray when it is being used.
Corn borers	Late season	carbaryl acephate	2 1	Foliage and fruit	When fruit is present on plant. Apply every 5 days when borers are present.
		carbofuran	2-3	Soilband to transplant	Make 2 applications; first, 3 weeks after transplant, second, 5 weeks later.

* Use restricted to certified applicators only.

ASPARAGUS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Asparagus beetles (NHE-49)	Early and mid-season on spears and ferns	carbaryl[1] malathion[1]	1½ 1	Spears and ferns	As needed, not more often than every 3 days.
		rotenone[1]	0.2-0.4	Spears	As needed.

[1] One-day restriction between last application and harvest.

SWEET CORN

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Soil insects (NHE-26, 27, 43)	April-August	Amaze Counter diazinon Dyfonate Lorsban Mocap phorate	1 1 1 1 1 1 1	Row	Apply on soil surface behind planter shoe and ahead of press wheel. Rootworm control may be needed if the corn was not sprayed the previous year.
Cutworms (NHE-38)	April-June	carbaryl[1] Lorsban 4E	2-3 1½	Base of plants Broadcast	When first damage appears.
Flea beetles (NHE-36)	April-July	carbaryl[1] carbofuran 10G	1½ 1	Foliage Soilband	As necessary.
Japanese beetles (NHE-32)	July-September	carbaryl[1]	1	Ear zone	As necessary.
First-generation corn borers	June	carbaryl[1]	2	Foliage	Make first application when tassel ratio is 30 to 40. Repeat in 4 to 5 days.
Second-generation corn borers and corn earworms[2] (NHE-33)	June-September	carbaryl[1] carbofuran 4F[3] fenvalerate *methomyl	2 ½ 0.1-0.2 0.45	Ear zone	*Fresh market corn:* At first silk and every 2 to 3 days for 5 to 8 applications. *Canning corn:* Observe light traps for earworm and borer adults, or keep a record of the heat units. When 1,500 or more heat units have accumulated, begin a spray program. As an alternative, begin at 30 to 50% silk and every 3 days thereafter until the corn is within 8 to 12 days of harvest.
Sap beetles (NHE-10) Picnic beetles	July-September	carbaryl[1] diazinon malathion *parathion	2 1 1 ½	Foliage	When adults first appear in field; usually between pollen-shedding and silk-drying.
Corn leaf aphids (NHE-29)	July-September	malathion *parathion	1 ½	Foliage	As needed to produce attractive ears for fresh market.
Fall armyworms	July-September	*methomyl *parathion	0.45 ½	Foliage	Apply to ear zone when whorl feeding is evident.

* Use restricted to certified applicators only.

[1] During pollen shed, apply carbaryl as late in the day as possible (preferably after 4 p.m.) to reduce bee kill. [2] Adding 0.5 to 0.75 pound of parathion or 0.25 to 0.45 pound of methomyl to carbaryl improves earworm control. [3] Corn borer control only.

ONIONS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Onion maggots (NHE-50)	All season	diazinon W.P. ethion W.P.	½-1 for 40-50 lb. of seed 1 for 40-50 lb. of seed	Seed	Seed treatment for set onions only. Use lighter dosage of diazinon on sandy, highly mineral soils.
		Dasanit granules diazinon granules Dyfonate ethion granules	1 ½-1 1 ½-2	Furrow	Use 1 lb. active ingredient per acre for rows 12″ apart; ¾ lb. for rows 18″ apart; ½ lb. for rows 24″ apart. Up to twice these amounts are needed for ethion on muck soils. Do not use Dasanit or Dyfonate on green onions.
		diazinon	2	Broadcast	Preplanting; disk into upper 1 to 2 inches of soil. Supplement with foliage spray below.
		diazinon malathion	⅓ 1	Foliage	Supplemental to soil treatment. Make first application when first adult flies are seen; make another 1 week later. From then on only as necessary.
Thrips (NHE-48)	Midseason and late season	diazinon malathion *azinphosmethyl	½ 1 ½	Foliage	When injury first appears and every 10 days as necessary.

* Use restricted to certified applicators only.

POTATOES

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Flea beetles	May-July	carbaryl	1	Foliage	When damage first appears on the leaves. Repeat as needed.
		carbofuran granules	3	In furrow	Planting time.
		carbofuran spray	1	Foliage	As needed.
		fenvalerate	0.1	Foliage	As needed.
		*methomyl	0.45	Foliage	As needed.
Colorado potato beetles; cutworms; potato leafhoppers (NHE-22)	May-July	carbaryl	2	Foliage	As needed.
		carbofuran granules	3	In furrow	Planting time.
		carbofuran spray	1	Foliage	As needed.
		dimethoate	0.3	Foliage	As needed.
		fenvalerate	0.1	Foliage	As needed.
		phorate granules	2-3	Soilband	Place on either or both sides of row at planting, but not in contact with seed. Use the lower rate on sandy soils, the heavier rate on heavy soils. Do not use on muck soils.
Aphids (NHE-47)	All season	dimethoate	0.3	Foliage	As needed.
		*methomyl	0.45		
		*parathion	¼		
		phorate granules	2-3	Soilband	Same as for leafhoppers.
Blister beetles (NHE-72)	All season	carbaryl	1½	Foliage	As needed.
Wireworms (NHE-43) White grubs (NHE-23)	All season	phorate granules	2-3	Soil	Preplanting, disk in; or use as soilband at planting.
Grasshoppers (NHE-74)	July-September	carbaryl	¾	Foliage	As needed, control in fence rows, roadsides, ditch banks, etc., before migration.
		dimethoate	0.3		

* Use restricted to certified applicators only.

PEAS

Insect	Time of attack	Insecticide	Pounds of active ingredient per acre	Placement	Timing of application
Caterpillars, including loopers	June	*methomyl	½-1	Foliage	Before harvest if worms are present.
Aphids	May-June	dimethoate	⅓	Foliage	As needed.

* Use restricted to certified applicators only.

FOR ADDITIONAL INFORMATION

Obtain the following circulars on insect control from the Office of Agricultural Publications, 123 Mumford Hall, 1301 W. Gregory Drive, Urbana, Illinois 61801.

Circular 899, 1983 Insect Pest Management Guide — Field and Forage Crops

Circular 900, 1983 Insect Pest Management Guide — Home, Yard, and Garden

Circular 1076, 1983 Turfgrass Pest Control

Leaflets describing the life history, biology, and habits of some of the insects mentioned can be obtained from the offices of county Extension advisers or by writing to Entomology Extension, 172 Natural Resources Building, 607 E. Peabody Drive, Champaign, Illinois 61820. These are indicated by an NHE number in the tables.

FOR YOUR PROTECTION--When using insecticides, always follow the guidelines listed on page 204.

1983 Insect Pest Management Guide

LIVESTOCK and LIVESTOCK BARNS

You must be certified as a pesticide applicator to use restricted-use pesticides. See your county Extension adviser in agriculture for information.

Livestock producers must manage insect pests to attain maximum production. Meat, milk, wool, and egg production can be reduced by flies, lice, mites, ticks, and grubs because these pests irritate animals and some suck their blood. Occasionally, animals have even been killed by attacks of large numbers of pests like horse flies, lice, and mites. Also, several of these pests transmit diseases from animal to animal. As a result, losses from pests each year cost Illinois farmers millions of dollars. A livestock producer, however, does not need to share his profits with insects — these pests can be managed effectively.

A complete insect pest-management program includes the wise selection of cultural, mechanical, biological, and chemical methods for the major insect pests of livestock and livestock barns. Insecticides, however, are still the most efficient means of managing most insect problems, and only the safest, most effective insecticides are suggested in this circular for each specific insect on each type of livestock. Other insecticides that may have label approval for use on livestock are not included because they are less effective or more toxic or present potential residue problems. Blank spaces in the table of limitations (Table 3) indicate that we do not suggest the insecticide for that specific use in Illinois.

When using insecticides, read the label and follow instructions. Do not exceed the rates suggested, observe the interval between application and slaughter, and apply the insecticide only to those animals for which use has been approved. Keep a record of the insecticide used, trade name, percentage of active ingredients, dilution, rate of application, and dates of application so that if you are ever questioned you will have the records.

Most of the insecticides are suggested for use as emulsion concentrates because these formulations are the easiest to handle. Wettable powders can be substituted if the finished spray is well agitated.

In the tables, the common chemical names are not capitalized. Trade names, however, are capitalized. In Table 3, common names are listed first. If the trade name is more commonly used, it is listed in parentheses after the common name. In Tables 1 and 2, only the common name is used if there is one. If you need to know the trade name, refer to Table 3.

These suggestions are printed annually, so you should always use the current year's issue. Labels may be cancelled and a product removed from the market at any time, and new labels may be granted. We have attempted to anticipate any further label changes, but there may be an occasional change between issues. *None of the insecticides listed in this circular has been classified for restricted use by the U.S. Environmental Protection Agency.* We will make announcements of any further label changes through the news media to keep you up to date. If you are not sure about the insecticide you plan to use, check with your county Extension adviser.

The Illinois Department of Public Health has announced that it is illegal for dairymen to apply or store chlorinated-hydrocarbon insecticides — aldrin, chlordane, dieldrin, endrin, lindane, or heptachlor — on their farms, except for use in farm residences. Previously, use of DDT had already been prohibited except by permit from the Illinois Department of Agriculture or Public Health.

These suggestions were prepared by entomologists of the University of Illinois College of Agriculture and the Illinois Natural History Survey. Although our suggestions for the use of insecticides are based on available data, factors such as rainfall and temperature can affect the efficiency of insecticides. Report the details of any control failures to us.

Leaflets describing the life history, biology, and habits of some of the insects mentioned in this circular can be obtained from the offices of county Extension advisers or by writing to Entomology Extension, 172 Natural Resources Building, 607 E. Peabody Drive, Champaign, IL 61820. These leaflets are indicated by an NHE number in the tables. In addition, the following circulars are available from the Office of Agricultural Publications, 123 Mumford Hall, 1301 W. Gregory Drive, Urbana, IL 61801: Circular 899, 1983 Insect Pest Management Guide — Field Crops; Circular 900, 1983 Insect Pest Management Guide — Home, Yard, and Garden; Circular 925, Insect Pests of Cattle; Circular 1136, Alfalfa Weevil Pest Management Program.

Circular 898

Table 1. DAIRY CATTLE, BEEF CATTLE, SWINE, AND SHEEP
(Refer to the table of limitations before using insecticides)

	Insect	Insecticide	Amount per 100 gal. water or as directed	How to apply
Dairy Cattle	Lice and mange (NHE-18)	Ciovap {crotoxyphos 10.0% + dichlorvos 2.5% E.C.	2 gal.	1 gal. per animal. Spray entire animal to saturation. Make 2 treatments 14 days apart.
Pastured cattle only	Face flies[1] (NHE-106) Horn flies[1] (NHE-59) Stable flies[4] (NHE-61)	Ciovap 1.25% O.[2]	Ready to use	1-2 oz. per animal; 2-4 times per week.[3]
		Ciovap 12.5% E.C.	1 qt. per 3 gal. water	1 pt. per animal per week or 1-2 oz. per animal 2-4 times per week from small hand sprayer or mist blower.[8]
	Horn flies[1] Face flies	fenvalerate 8.0% eartags	Ready to use	Place tag on front side of each ear in May.
		permethrin 10.0% eartags[9]		
	Horse and deer flies[1] (NHE-60)	pyrethrin 0.5% + synergist O.[2]	Ready to use	2 oz. per animal 3 times per week.[3]
		pyrethrin 1% + synergist E.C.	10 gal.	1-2 pt. per animal every 3 days.[8]
	Horn flies[1]	crotoxyphos 3.0% D. or 1.0% O. coumaphos 1.0% D. or 1.0% O. stirofos 1.0% D. or 1.0% O. dichlorvos 0.25% O.	In dust bags or face and back oilers	Use only in exits of milk parlors, barns, or lanes. Apply daily. Only partially controls face and stable flies. Helps suppress lice infestations.
Beef Cattle	Lice and mange (NHE-18)	Ciovap 12.5% E.C.	2 gal.	1 gal. per animal. Spray animal to saturation. Make 2 applications 14 days apart.
	Lice	chlorpyrifos 43.2% E.C.	Ready to use	Apply 2 cc per 100 lb. bodyweight. Maximum of 16 cc per animal. Apply in spot on top line just behind shoulder.[8]
		fenthion 7.6% E.C.	1 pt. per gal. water	Apply 1 oz. per 100 lb. body weight. Maximum of 8 oz. per animal. Pour on topline from shoulders to hips. Repeat in 14 days.
Pastured cattle only	Face flies[1] Horn flies[1] Stable flies[4]	Ciovap 12.5% E.C.	1 qt. per 3 gal. water	1-2 oz. per animal; 2-4 times per week from a mist blower.[3]
				1 pt. per adult animal per week.[8]
		Ciovap 1.25% O.[2]	Ready to use	1-2 oz. per animal; 2-4 times per week.[3]
	Horn flies[1] Face flies	fenvalerate 8.0% eartags	Ready to use	Place tag on front side of each ear in May.
		permethrin 10.0% eartags[9]		
	Horse and deer flies[1]	Use as directed for dairy cattle above.		
	Horn flies[1]	Dust bags and oilers: Various insecticides are approved for use in face oilers, back oilers, and dust bags. Force treat if possible, but always place in location for greatest use. Only partially controls stable and face flies. Keep device well charged and in good working order.		
	Grubs	Systemic insecticides like coumaphos, famphur, fenthion, phosmet, and trichlorfon as sprays or pour-ons provide excellent control of grubs and good control of lice. Use only on ***native beef cattle*** in herds having a history of grub problems. Treat only those animals between 4 months and 2½ years of age. Apply during August or September in the southern half of the state and in September or October in the northern half of the state. Animals in confinement are not attacked by ox warble flies.		
Swine	Mange and lice	malathion 50–57% E.C.	1 gal.	2-4 qt. per animal. Spray animal to saturation. Make 2 applications 14 days apart.
	Lice	fenthion 3% O.	Ready to use	Apply ½ oz. per 100 lb. body weight. Pour on topline from neck to rump.
Sheep	Keds, lice, fleece-worms, and scab (NHE-53)	toxaphene 60% E.C.	3 qt.[5]	Spray animal to saturation or use in dipping vat for scab.[6]
	Keds and lice	diazinon 50% W.P.	½ oz. per 3 gal. water	Apply 1 qt. per animal from sprinkling can over back, head, and neck.[7]

Note: E.C. = emulsion concentrate, O. = oil solution, W.P. = wettable powder, D. = dust.

[1] Place cattle in barns or sheds to avoid attack by face flies, horn flies, horse flies, and deer flies. Apply treatments when there are fifteen or more face flies, fifty or more horn flies, or one or more horse flies per animal.

[2] Apply from small hand sprayer or automatic sprayer. The same dosage of a water-base spray may be used.

[3] Spray head, back, sides, belly, and legs carefully. Start treatments in May and continue to September.

[4] Remove decaying straw, hay, manure, and feed from barns and lots and spread to dry each week, or cover manure pile with black plastic so stable fly breeding will be reduced. Apply treatments when there are four or more stable flies per animal.

[5] Add 2 pounds of detergent per 100 gallons of spray for better wetting effects.

[6] Official scab eradication treatment used by the State Department of Agriculture. Involves two dippings 10-14 days apart. Isolate and treat incoming animals before introducing them into the flock.

[7] Stir the diazinon suspension frequently.

[8] Because of the small amount of material used, care must be taken to apply the proper dose. See Table 3 for precautions.

[9] A state-labeled insecticide. The applicator must have the label in possession when applying.

Table 2. GOATS, HORSES, CHICKENS, LIVESTOCK BARNS, AND SHEDS
(Refer to the table of limitations before using insecticides)

	Insect	Insecticide	Amount per 100 gal. water or as directed	How to apply
Goats *Pastured goats only*	Face flies[1] Stable flies	Ciovap 12.5% E.C.	1 qt. per 3 gal. water	Apply 1 pt. per animal per week.
	Horse and deer flies[1]		Use pyrethrin as directed for dairy cattle.	
	Lice	Ciovap 12.5% E.C.	2 gal.	Apply 2-4 qt. per animal. Repeat in 14 days.
Horses *Pastured horses only*	Face flies,[1] stable flies,[2] horse and deer flies[1]	pyrethrin 1.0% + synergist E.C.	1 pt. per 1 pt. water	Apply 1-2 oz. as a mist over the entire animal 2-4 times per week.[3]
	Black flies[1]	petroleum jelly	Ready to use	Apply a thin coating on inside of ears. Use pyrethrin as suggested above for flies.
	Lice	malathion 4.0-5.0% D.	3 tbl. per animal	Apply on back and neck of animals. Repeat in 14 days.
Chickens	Northern fowl mites, common red mites, bedbugs, and lice (NHE-54)	carbaryl 80% W.P.	4 oz. per 5 gal. water	Spray birds using 1 gal. per 100 birds for fowl mites and lice. Use 125 psi pressure when treating for fowl mites. Spray roosts, walls, and around nests for red mites and bedbugs. Dust of 5% carbaryl, 0.5% coumaphos, 4% malathion, or 3% stirofos may be used on litter for control of northern fowl mites and lice. Keep wild birds from entering or nesting in poultry houses.
		coumaphos 25% W.P.	3 oz. per 5 gal. water[4]	
		malathion 50–57% E.C.	5 oz. per 5 gal. water[4]	
		Ravap {stirofos 23% + dichlorovos 6% E.C.}	13 oz. per 5 gal. water	
		stirofos 50% W.P.	6.5 oz. per 5 gal. water	
Residual Sprays for Livestock Barns and Sheds[2]	House flies (NHE-16, 88), stable flies, and other flies	dimethoate 23% E.C.	4 gal.	Start treatments in June and maintain good sanitation. Apply 2 gal. per 1,000 sq. ft. or apply to the point of runoff (drip) to ceilings, walls, and support posts and outside around doors and windows. Lasts about 2-4 weeks.[5]
		fenthion 45% E.C.	3 gal.	Lasts about 2-5 weeks.[5] Apply as for dimethoate.
		permethrin 5.7% E.C.[6]	2 gal.	Lasts about 3-7 weeks.[5] Apply 1 gal. per 750-1000 sq. ft.
		permethrin 10.0% E.C.[6]	1 gal.	
		permethrin 25% W.P.[6]	3⅓ to 6⅔ lb.	
		Ravap 29% E.C.	4 gal.	Lasts about 2-4 weeks.[5] Apply as for dimethoate.
		stirofos 50% W.P.	16 lb.	
Space Sprays for Feedlots and Sheds[2]	House flies, stable flies, and other flies	dichlorvos 23% E.C.	2 gal.	Apply 5 gal. per acre with mist blower over animals and pens every 3 to 7 days.
		dichlorvos 43% E.C.	1 gal.	
		naled 58% E.C.[7]	5 pts.	Apply as for dichlorvos.
		pyrethrin E.C.	Dilute to 0.1% with water	Apply as for dichlorvos.
Baits as Supplements for Livestock Barn and Shed Sprays[2]	House flies	dichlorvos 23% E.C.	4 oz. per 1 gal. corn sirup + ½ gal. warm water	Apply to favorite fly-roosting areas from tank sprayer as needed to supplement residual spray treatment.
		naled 58% E.C.	1 oz. per 1 gal. corn sirup + ½ gal. warm water	Apply as for dichlorvos.

Note: E.C. = emulsion concentrate, O. = oil solution, W.P. = wettable powder, D = dust.

[1] Place horses or goats in barns or sheds to avoid attack by face flies, black flies, horse flies, and deer flies.

[2] Good sanitation is the basic step in barn fly control (house and stable flies). Remove manure, decaying straw, hay, and feed and spread to dry each week, or cover manure pile with black plastic. Leave an 8-inch residue of manure in the pits or pens if the interval between cleanups is more than 1 week.

[3] Spraying may upset horses. Avoid getting spray into the animal's eyes.

[4] Double the insecticide-to-water ratio for spraying roosts, walls, and around nests.

[5] Lasting effects are shortened during periods of hot, dry weather.

[6] A state-labeled insecticide. The applicator must have the label in possession when applying.

[7] Temporary stinging of eyes may occur from mist but is not hazardous. Rinse equipment thoroughly after use to avoid corrosion.

Table 3. LIMITATIONS FOR SUGGESTED INSECTICIDES APPLIED TO LIVESTOCK OR IN LIVESTOCK BARNS
(Blank spaces in the table mean that the material is not suggested for that specific use in Illinois)

	Dairy		Beef		Swine		Sheep		Goats		Horses		Chickens	
	Animals	Barns	Animals	Barns	Animals	Barns	Animals	Barns	Animals	Barns	Animals	Barns	Birds	Barns
carbaryl (Sevin)	...	...	...	...	...	...	...	...	...	...	...	...	A,B	A,B
chlorpyrifos (Dursban)	...	...	C,D,S	...	...	...	...	...	...	...	...	...	...	...
Ciovap	C,D,F	...	C,D,F	...	...	...	...	...	C,D,F,G	...	...	...	...	...
coumaphos (Coral)	C,D	...	C,D,E	...	...	...	...	...	...	...	...	...	B	B
crotoxyphos (Ciodrin)	C,D,F	...	C,D,F	...	...	...	...	...	...	...	...	...	...	...
diazinon	...	...	...	...	...	...	C,D,I	...	...	...	...	...	...	...
dichlorvos (DDVP) (Vapona)	C,D	J,K	C,D	J,K	...	J,K	...	J,K	...	J,K	...	J,K	...	J
dimethoate (Cygon)	...	D,H,V	...	D,H,V	...	D,H,V	...	D,H,V	...	D,H,V	...	D,H,V	...	B,H,V
famphur (Warbex)	...	...	C,D,E,R	...	...	...	...	...	...	...	...	...	...	...
fenthion (Baytex, Tiguvon, Lysoff)	...	C,D	C,D,E,L	C,D	M,N	...	...	...	...	...	...	...	...	B
fenvalerate (Ectrin)	C,T	...	C,T	...	...	...	...	...	...	...	...	...	...	...
malathion	...	...	...	...	C,D	...	...	...	...	...	C,D	...	B	B
naled (Dibrom)	...	C,J,K	...	J,K	...	J,K	...	J,K	...	J,K	...	J,K	...	J
permethrin (Ectiban, Permectrin, Insectrin, Overtime, Hard Hitter, Atroban, Gardstar, Insectaban)	C,T	B,M,U	C,T	B,M,U	...	B,M,U	...	B,M,U	...	...	...	B,M,U	...	B,M,U
phosmet (Prolate)	...	...	C,D,E,O	...	...	...	...	...	...	...	...	...	...	...
pyrethrin	C	K	C	K	...	K	...	K	C	K	C	K	...	...
Ravap	...	C,D	...	C,D	...	C,D	...	C,D	...	C,D	...	C,D	B,P	B
stirofos (Rabon)	C,D	C,D	C,D	C,D	...	C,D	...	C,D	...	C,D	C,D	C,D	B,P	B
toxaphene	...	...	...	...	...	...	C,Q	...	...	...	...	...	...	...
trichlorfon (Neguvon)	...	...	C,D,E,M	...	...	...	...	...	...	...	...	...	...	...

A. Do not apply within 7 days of slaughter and do not treat nesting material. Do not repeat within 4 weeks.
B. Gather eggs before treatment and do not contaminate feed and water.
C. Do not contaminate feed, water, milk, or milking equipment.
D. Do not apply in conjunction with the feeding of phenothiazine or organophosphate insecticides.
E. Do not treat: animals less than 6 months old; sick or stressed animals within 10 days of shipping; or animals in a confined, nonventilated area.
F. Do not apply within 1 day of slaughter and do not treat Brahman cattle.
G. Do not repeat more often than every 7 days.
H. When used as a spray, remove animals before treating barn. Do not contaminate feed, water, eggs, milk, or milking equipment. Do not use in milk storage rooms. Do not apply to animals.
I. Do not apply within 14 days of slaughter. Do not treat lambs less than 2 weeks old.
J. As a bait. Do not apply within reach of animals or in milk rooms. Do not contaminate feed, water, eggs, milk, or equipment.
K. As a space spray in feedlots, corrals, or pens; may be applied with animals present, but avoid direct application to exposed feed and water. Do not apply in conjunction with the feeding of phenothiazine or the feeding or use as animal or shelter treatments of organophosphate or carbamate insecticides.
L. Do not apply within 45 days of slaughter.
M. Do not apply within 14 days of slaughter.
N. Do not use in conjunction with organophosphate or carbamate insecticides.
O. Do not apply within 21 days of slaughter. Do not repeat treatment within 10 days.
P. Do not repeat more often than every 14 days. If used on walls for fly control, do not apply to birds.
Q. Do not apply within 28 days of slaughter.
R. Do not apply within 35 days of slaughter.
S. Do not treat dairy cattle, continental or exotic breed cattle, bulls, cows within 21 days before or 14 days after calving, veal calves, calves under 12 weeks old, animals under 200 pounds, sick or stressed animals, or cattle 10 days before or after shipping, dehorning, castration, vaccination, etc. Do not slaughter animals within 14 days of treatment. A retreatment may be applied in 30 days, but cattle then may not be slaughtered for 21 days after the second treatment. Do not use any drug or chemical that is a cholinesterase inhibitor simultaneously or within 45 days before or after treatment.
T. Remove tags before slaughter.
U. Do not treat manure or litter. Do not apply directly to animals. Cover all feed and water supplies. Do not retreat more than once every 2 weeks.
V. Protective clothing must be worn during application.

FOR YOUR PROTECTION

1. Wear rubber gloves when handling insecticide concentrates.
2. Do not smoke while handling or using insecticides.
3. Keep your face turned to one side when opening insecticide containers.
4. Leave unused insecticides in their original containers with the labels on them.
5. Store insecticides out of the reach of children, irresponsible persons, or animals; store preferably in a locked cabinet or room, away from food, feed, or water.
6. Triple-rinse, puncture, and bury or burn empty containers, or take them to an approved sanitary landfill.
7. Do not put the water-supply hose directly into the spray tank.
8. Do not blow out clogged nozzles or spray lines with your mouth.
9. Wash with soap and water all exposed parts of the body and clothes contaminated with insecticide.
10. Do not leave puddles of spray on impervious surfaces.
11. Do not apply to or allow runoff into fish-bearing or other water supplies. Do not allow treated animals in fish-bearing or other water supplies until the spray has dried.
12. Do not apply insecticides, except in an emergency, to areas with abundant wildlife or to blossoming crops visited by bees. Avoid drift onto blossoming crops and onto beehives.
13. Do not apply insecticides near dug wells or cisterns.
14. Do not spray when weather conditions favor drift.
15. Follow all directions and precautions on the label.

1983 Insect Pest Management Guide

FIELD and FORAGE CROPS

You must be certified as a pesticide applicator to use restricted-use pesticides. See your county Extension adviser in agriculture for information.

FEDERAL AND STATE LAWS

The U.S. Environmental Protection Agency is classifying pesticides for "general" or "restricted" use. Anyone applying a restricted-use pesticide must be certified. Only a few pesticides have been classified.

Commercial applicators who apply restricted-use pesticides must be certified. Commercial applicators include not only persons applying a pesticide for hire but also governmental personnel, chemical company representatives, and others involved in demonstrational, regulatory, and public health pest control. Certification as a commercial applicator requires passing a written examination administered either by the Illinois Department of Agriculture or the Department of Public Health.

Private applicators who use restricted-use pesticides "for the purpose of producing any agricultural commodity on property owned or rented by him or as exchange labor (no compensation) on the property of another" must also be certified, either by attending an educational training program or by passing an examination.

Educational training programs for farmers (private applicators) and commercial pesticide applicators are conducted by the Cooperative Extension Service to prepare persons for certification. For additional information, consult your county Extension adviser in agriculture. The actual certification and the issuing of permits or licenses are handled by the Illinois Department of Agriculture or the Illinois Department of Public Health.

Special Local Need Registrations

Section 24(c) of the amendments to the Federal Insecticide, Fungicide, and Rodenticide Act of 1972 allows states the right to register pesticides for use within the state to meet special local needs (SLN). The authority for state registration of pesticides is the Illinois Department of Agriculture. A special label, which lists the new 24(c) uses, is printed by the formulator. A copy of this label must be in the possession of the operator during application of the pesticides.

In the following pages, all SLN, or 24(c), registrations are indicated by this sign: †.

Insecticides and Classifications

At the time this publication was in preparation, only a few of the insecticides listed below had been classified for either "restricted" or "general" use by the EPA. Additional insecticides are expected to be classified before the 1983 planting season. Your county Extension adviser will have additional information on insecticide restrictions.

The chemical names used in this circular may be unfamiliar to you. These names are the common, coined

Table 1. Insecticide Classifications

Common name	*Trade name*	*Classification*
acephate	Orthene	unclassified
Bacillus thuringiensis	Dipel, Thuricide, Bactur, SOK	unclassified
carbaryl	Sevin, Savit	unclassified
carbofuran	*Furadan	restricted[a]
chlorpyrifos	Lorsban	unclassified
diazinon	Diazinon	unclassified
dimethoate	Cygon, De-Fend	unclassified
disulfoton	*Di-Syston	restricted[a]
ethion	Ethion	unclassified
ethoprop	*Mocap	restricted[a]
fenvalerate	*Pydrin	restricted[b]
fonofos	*Dyfonate	restricted[a]
isofenphos	*Amaze	restricted[b]
malathion	Cythion, malathion	unclassified
methidathion	*Supracide	restricted[b]
methomyl	*Lannate, *Nudrin	restricted[c]
methoxychlor	methoxychlor	unclassified
methyl parathion	*Methyl parathion	restricted[b]
methyl parathion (microencapsulated)	*Penncap-M	restricted[b]
phorate	Thimet	unclassified
phosmet	Imidan	unclassified
terbufos	Counter	unclassified
trichlorfon	Dylox, Proxol	unclassified

[a] Liquid formulations are restricted.
[b] All formulations are restricted.
[c] All formulations except water-soluble packages, 25% wettable powder, and granulars are restricted.

Asterisks (*) are used throughout this circular to indicate insecticides classified for "restricted" use.

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chemical names and as such are not capitalized (for example, terbufos). Trade names are capitalized (for example, Counter). In the table of limitations (Table 15), the trade names are listed first, with the common name in parentheses following the trade name. In the tables of suggestions, the trade name is also listed first and the common name is in parentheses. For questions, refer to Table 1 or to Table 15.

POLICY STATEMENT

The *Illinois Insect Pest Management Guide: Field and Forage Crops* (Circular 899) is revised annually and is intended for use during the current calendar year only. Not all registered insecticides for crop pests are included in this circular. Insecticides that are effective and do not present an undue hazard to the user are suggested whenever possible.

Trade names have been used for simplicity, but their usage does not imply endorsement of one product over another, nor is discrimination intended against any product.

This guide for insect control is based on research results from the Illinois Natural History Survey, the University of Illinois Agricultural Experiment Station, other experiment stations, and the U.S. Department of Agriculture.

Requested label clearances for a few uses of some insecticides, carriers, and solvents are uncertain for 1983 because many requests have not yet been officially cleared. Be sure to check with your county Extension adviser in agriculture if you are in doubt about an insecticide you plan to use. We will make announcements of label changes through the news media to keep you up to date.

REFERENCES

This circular lists only suggested uses of insecticides for the control of many pests in Illinois field crops and is not designed to discuss other methods of control. Fact sheets discussing nonchemical control methods, descriptions of specific insects, and their life history and biology (designated by NHE numbers) can be obtained from the office of the county Extension adviser in agriculture or by writing to Entomology Extension, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, IL 61820.

PEST-MANAGEMENT SCOUTING PROGRAMS

Integrated Pest Management (IPM) and pest scouting have become increasingly important in the past 10 years. IPM is a systematic method of looking for pests in the field, of determining whether any control measures are needed, and if there is a problem, of deciding on the proper measures to use. Pest scouting enables farmers to detect and control pest outbreaks before significant yield losses occur. Because decisions on chemical control are based on economic thresholds and not on guesswork, these programs also keep unnecessary pesticide use to a minimum.

Pest scouting has been accepted as an important management tool by many Illinois farmers in the past several years. As farming costs increase, growers are realizing the advantages of treating a field only when an economically harmful pest population occurs, rather than treating it automatically regardless of the situation. By using pesticides on this basis, farmers have a better chance of reducing management costs.

Pest scouting programs have been initiated by several pest-management consulting firms throughout the state. They offer the farmer scouting services, soil testing services, nematode monitoring, and various other kinds of services.

PESTICIDE SAFETY

Certain precautionary steps should be taken when handling insecticides. Some of the insecticides suggested in this publication can be poisonous to the applicator. The farmer is expected to protect himself, his workers, and his family from needless exposure.

When using insecticides, apply all the scientific knowledge available to make sure that there will be no illegal residue on the marketed crop. Such knowledge is condensed on the label. READ THE LABEL CAREFULLY AND FOLLOW THE INSTRUCTIONS. The label should be recent and not from a container several years old. Do not exceed the maximum rates suggested. Observe the interval between application and harvest. Apply only to crops for which use has been approved. Keep records of pesticide use for each field. Record the product used, the trade name, the percentage content of the insecticide, the dilution, the rate of application per acre, and the date or dates of application.

Always handle insecticides with respect. The persons most likely to suffer ill effects from insecticides are the applicator and his family. Accidents and careless, needless overexposure can be avoided. Following these rules will prevent most insecticide accidents:

1. Wear rubber gloves when handling insecticide concentrates.
2. Do not smoke while handling or using insecticides.
3. Keep your face turned to one side when opening, pouring from, or emptying insecticide containers.
4. Leave unused insecticides in their original containers with the labels on them.
5. Store insecticides out of the reach of children, irresponsible persons, or animals; store preferably in a locked building. Do not store near livestock feeds. Better yet, buy no more pesticide than you will use, thus eliminating a pesticide storage and disposal problem.
6. Triple rinse, bury, or burn all empty insecticide containers or take them to an appropriate sanitary landfill.
7. Do not put the water-supply hose directly into the

spray tank or blow out clogged nozzles or spray lines with your mouth.

8. Wash with soap and water exposed parts of the body and clothes contaminated with insecticides.

9. Do not apply to fish-bearing or other waters.

10. Do not leave puddles of spray on impervious surfaces or apply insecticides near dug wells or cisterns.

11. Do not apply insecticides, except in an emergency, to areas with abundant wildlife.

12. Do not spray or dust when weather favors drift.

13. To avoid bee kill, apply insecticides after bee activity has been completed for the day; use the least toxic materials. *Warn beekeepers that you are applying insecticides.*

PREDICTING THE NEED FOR SOIL INSECTICIDES ON CORN

The type of crop rotation greatly influences whether a soil insect problem will occur and what kind it will be. Some guidelines follow for predicting soil insect problems in corn and for determining the need to use a soil insecticide at planting time. Exceptions can be expected occasionally because soil insect problems are influenced by a variety of things unrelated to crop rotation, such as the weather, soil type, planting date, hybrid, tillage, and natural enemies. Knowledge about soil insect damage in a particular field during previous years is also helpful because infestations tend to occur in the same fields and in the same area.

Corn After Soybeans. The potential for soil insect problems in corn after soybeans is generally low, and the use of soil insecticides rarely pays. In most fields, a diazinon planter-box seed treatment will be adequate to protect against attack by seedcorn beetles and seedcorn maggots. Corn rootworms rarely cause damage to corn after soybeans.

White grubs are an occasional problem in east-central Illinois in corn after soybeans.

Corn After Corn. The potential for rootworm damage is moderate to severe in the northern two-thirds of Illinois. A rootworm insecticide may be needed in most fields of corn after corn. Wireworms are occasionally a problem in the southern part of Illinois.

Corn After Grass Sod. Wireworms and white grubs are potential problems. Apply a labeled soil insecticide at planting time.

Corn After Legumes. Grape colaspis, grubs, wireworms, and cutworms are potential problems in corn after clover and alfalfa. In northern Illinois, rootworms are occasionally a problem in corn following clover or alfalfa. Apply a soil insecticide at planting time.

Corn After Small Grain. There is a slight potential for damage by wireworms, seedcorn beetles, and seedcorn maggots in corn after small grain. In most instances, a diazinon + lindane planter-box seed treatment will be adequate. If wireworms are present, use a soil insecticide at planting time.

CORN ROOTWORM SITUATION

Problem Area

The potential for rootworm damage to corn following corn is greatest in the northern two-thirds of the state. Although in most counties populations of northern and western corn rootworm beetles were lower during 1982 than in 1981, moderate to severe damage to corn roots by larvae may occur in continuous corn anywhere in Illinois.

Determining Potential

Corn growers should base the need for using a rootworm soil insecticide in 1983 on the abundance of rootworm beetles in cornfields during late summer of 1982. If beetle numbers reached or exceeded one per plant at any time during late July, August, or September, 1982, plan to apply a rootworm soil insecticide if the field is to be replanted to corn in 1983.

Fields of corn planted in late May or June, 1982, may have extensive rootworm damage if replanted to corn in 1983. During August and September, rootworm beetles are especially attracted to late planted or late maturing fields. Seeking fresh pollen and silks to feed on, the beetles lay millions of eggs in these fields. The heavy infestations may overwhelm even the most effective soil insecticide. Planting the fields to a crop other than corn in 1983 is suggested to reduce the rootworm population.

SUGGESTIONS FOR ROOTWORM CONTROL, 1983

Crop Rotation

Crop rotation is an extremely effective way to prevent damage by northern and western corn rootworm larvae. If feasible, do not grow corn two years in succession in the same field. First-year corn following soybeans will generally *not* require a soil insecticide for rootworm control.

Although rootworm beetles can be found in "clean" or weed-free soybean fields, and may even lay a few eggs there, the number of eggs is not great enough to warrant the use of a soil insecticide on corn the following season. In a few instances, rootworm larval damage has occurred to corn planted after soybeans when the bean field had been heavily infested with volunteer corn or weeds during August. Adult northern and western corn rootworms were attracted to these weedy soybean fields to deposit eggs. As a result, root damage by larvae occurred the following season. Good weed control in soybeans will prevent rootworm damage in corn following soybeans. Soybean fields with 5,000 or more volunteer corn plants per acre will usually warrant treatment for rootworm control the following year if planted to corn.

Corn rootworm beetles deposit the vast majority of their eggs in cornfields. The larvae cannot survive on the roots of broadleaf crops (soybeans or alfalfa) or broadleaf weeds. Consequently, when a crop other than corn, soybeans for example, is planted in a field with soil containing millions of rootworm eggs, the rootworm larvae die before becoming egg-laying beetles.

Soil Insecticides

Many factors interacting with one another can affect the performance of a soil insecticide. Heavy rains immediately following planting hasten the decomposition of soil insecticides and reduce control. Lack of rainfall may prevent the activation and movement of the insecticide from the soil surface to the area where rootworm larvae are feeding. Early planting is another problem, because soil insecticides applied in early to mid-April may have lost much of their potency by the time rootworm eggs hatch in late May and June. Hence, late hatching larvae have a high survival rate, and ultimately the number of beetles is large. These factors, coupled with insecticide rates that are too low, often cause poor or marginal rootworm control. In addition, some research indicates that the erratic performance is due to microbial degradation of the soil insecticide and to increasing tolerance of rootworm larvae.

The suggestions for rootworm control that follow are based on research conducted by entomologists in Illinois and other states.

At Planting. Apply isofenphos (Amaze 20G, 6E), terbufos (Counter 15G), fonofos (Dyfonate 20G, 4EC), carbofuran (Furadan 15G, 4F), chlorpyrifos (Lorsban 15G), ethoprop (Mocap 10G, 6EC), or phorate (Thimet 20G) in a 7-inch band ahead of the planter press wheel at the suggested rate (see Table 2). IMPORTANT: Note the suggestions in the section on alternating rootworm soil insecticides.

Soil insecticides will give 50- to 70-percent control of corn rootworm larvae. This degree of control is adequate to prevent economic levels of larval damage in most fields. But in some heavily infested fields, enough larvae may survive to cause economic levels of root damage, and beetle populations may be large enough to interfere with pollination.

Planting-time treatments applied in early April may provide only marginal control. Consider a cultivator application in late May or early June in such fields, rather than a treatment at planting time.

Liquid formulations: Isofenphos (Amaze 6E), fonofos (Dyfonate 4E), or carbofuran (Furadan 4F) may be mixed with water and applied as a spray in a 7-inch band ahead of the press wheel. They may also be mixed with liquid fertilizer and used with a split-boot applicator at planting. Ethoprop (Mocap EC) is labeled only as a band spray mixed with water.

Incompatibility or crop injury may be a problem in treatments using a liquid insecticide with a liquid fertilizer at planting. The insecticide *must* be compatible with the fertilizer. Conduct a test before planting to make certain that the two are physically compatible. Maintain agitation in the tank after mixing and during application to prevent separation. **Use caution when handling liquid insecticide formulations.**

At Cultivation. Apply isofenphos (Amaze 20G, 6E), terbufos (Counter 15G), chlorpyrifos (Lorsban 15G), fonofos (Dyfonate 20G), ethoprop (Mocap 10G), carbofuran (Furadan 15G), or phorate (Thimet 20G) on both sides of the row at the base of the plants just ahead of the cultivator shovels. Cover the insecticides with soil. The best time to apply a basal treatment of a soil insecticide by cultivator is in late May or early June, near the beginning of egg hatch. Such treatments may be more effective than treatments at planting time in early April.

Suggestions For Alternating Rootworm Soil Insecticides. Rootworm control with carbofuran (Furadan) has been erratic in recent years. Furadan has performed effectively at some research locations and has been marginal or ineffective at others.

Consider the following suggestions for alternating rootworm soil insecticides:

Table 2. Soil Insecticides Suggested For Rootworm Control, Illinois, 1983

Insecticide[a]	Time of application	Ounces of product per 1,000 ft. of row	Amount of product needed per acre			
			40″ rows	38″ rows	36″ rows	30″ rows
Amaze 20G	At planting or cultivation	6	5.0 lb.	5.3 lb.	5.6 lb.	6.7 lb.
Amaze 6E	At planting or cultivation	1.6 fl. oz.	1⅓ pints	1⅜ pints	1½ pints	1¾ pints
Counter 15G	At planting or cultivation	8	6.7 lb.	7.0 lb.	7.4 lb.	8.7 lb.
Dyfonate 20G	At planting or cultivation	6	5.0 lb.	5.3 lb.	5.6 lb.	6.7 lb.
Dyfonate 4E	At planting	2.4 fl. oz.	2 pints	2⅛ pints	2¼ pints	2¾ pints
Dyfonate 4E	Preplant	Broadcast	3 quarts	3 quarts	3 quarts	3 quarts
Furadan 15G	At planting or cultivation	8	6.7 lb.	7.0 lb.	7.4 lb.	8.7 lb.
Furadan 4F	At planting	2.4 fl. oz.	2 pints	2⅛ pints	2¼ pints	2¾ pints
Lorsban 15G	At planting or cultivation	8	6.7 lb.	7.0 lb.	7.4 lb.	8.7 lb.
Mocap 10G	At planting or cultivation	12	10.0 lb.	10.5 lb.	11.1 lb.	13.3 lb.
Mocap 6EC	At planting	1.6 fl. oz.	1⅓ pints	1⅜ pints	1½ pints	1¾ pints
Thimet 20G	At planting or cultivation	6	5.0 lb.	5.3 lb.	5.6 lb.	6.7 lb.

[a] Consult text for more information. LIQUID FORMULATIONS ARE HIGHLY TOXIC.

Table 3. Labeled Uses of Soil Insecticides on Corn

Insecticide	Field corn	Popcorn	Sweet corn	silage	Harvest interval
Amaze	yes	yes	yes	yes	75
Counter	yes	yes	yes	yes	*
Dyfonate	yes	yes	yes	yes	45
Furadan	yes	yes	yes	yes	*
Lorsban	yes	yes	yes	yes	*
Mocap	yes	no	yes	yes	*
Thimet	yes	no	yes	yes	30

* No restriction when used according to label.

1. If Furadan was used in 1982, switch to an organophosphate (Amaze, Counter, Dyfonate, Mocap, Lorsban, or Thimet) in 1983.
2. Do not use Furadan if rootworm control with Furadan was poor or marginal in recent years.
3. Rootworm control with Furadan should be satisfactory in fields where it has never been used before.
4. Consider alternating an organophosphate with a carbamate. Keep in mind, however, that growers generally have had no advance warning of poor control where problems with Furadan (a carbamate) have occurred.

The advantages of switching from an organophosphate to a carbamate are not apparent from the research, even where an organophosphate has been used for several consecutive years. But switching from one organophosphate to another may have some merit. The continuous use of any one insecticide may create problems with insect resistance. To avoid this possibility, consider switching rootworm insecticides occasionally rather than using one product year after year. A word of caution, however, about rotating soil insecticides: in some instances, rotation of soil insecticides has not given good results. The performance of an insecticide that gives only fair control of rootworms will not be improved by rotation with other insecticides.

Scouting to Determine Rootworm Potential

The abundance of rootworm beetles in a cornfield in July and August is an excellent indicator of future rootworm problems. Corn growers can determine the potential for rootworm damage in 1984 by counting western and northern corn rootworm beetles from mid-July through August, 1983, in this way:

1. Make 3 or more counts for western and northern corn rootworm beetles at 7- to 10-day intervals between mid-July and late August in fields to be replanted to corn.
2. Examine 10 plants selected at random in each of 5 areas of the field. Count all of the western and northern corn rootworm beetles on 50 plants each time. The counts take about 45 minutes in a 40-acre field.
3. As you approach a plant, move quietly to avoid disturbing the beetles. Count the beetles on the entire plant, including the ear tip, tassel, leaf surface, and behind the leaf axils.
4. Record the number of beetles you find per plant. If the average is more than one beetle per plant for any sampling date, plan to apply a rootworm soil insecticide in 1984. If average populations range from ½ to 1 beetle per plant, the probability of economic damage the following year is low, and a soil insecticide is likely to be unnecessary. If populations do not exceed an average of ½ beetle per plant for any sampling date, a soil insecticide will not be needed the following season.

Rootworm Life Cycle

Western and northern corn rootworm beetles deposit their eggs in the soil at the base of the corn plants or between rows during August and September. The eggs overwinter in the soil and begin hatching in late May. Egg hatch usually takes place over a period of 3 to 5 weeks. Consequently, in July and August all stages of the corn rootworm — egg, larva, pupa, and adult — may be found. The rootworm larvae feed on the roots of corn plants during June, July, and August. When a larva is fully grown (½ inch), it builds a cavity in the soil and goes into the pupal or resting stage. After 5 to 10 days, the beetle emerges from the soil. The development from egg hatch to adult emergence takes 27 to 40 days. After the females emerge from the soil and mate, 14 days or more elapse before they begin laying eggs. Rootworm beetles may deposit as many as 1,000 eggs; an average of 500 per female is probably common. Most egg laying in Illinois occurs after August 1.

CORN CUTWORMS

The occurrence and extent of cutworm infestations are difficult to predict each year. *Sandhill, dingy,* and *claybacked cutworms* all overwinter in Illinois as partially grown larvae, but their populations are seldom widespread. As a result, they cause damage early in the growing season in scattered areas. Sandhill cutworms are a problem in sandy areas almost every year. Dingy and claybacked cutworms occur more frequently in corn planted after sod or forage legumes than in other crop rotations.

Black cutworms do not overwinter in Illinois, so outbreaks are difficult to forecast. Infestations of black cutworm larvae arise from eggs laid by moths that are blown into Illinois in the early spring. A statewide program of monitoring black cutworm pheromone traps provides information about the time and intensity of spring moth flights. But this program is still in the preliminary stage, and predicting infestations from moth catches is risky.

Certain factors favor black cutworm outbreaks, however. These factors include late planting, infestations of broadleaf weeds before planting, crop residue, and corn following soybeans. The most important factors may be late planting and preplant weed infestations. Fields that are tilled and planted late are more likely to develop a preplant weed infestation than fields that are planted early.

These late-planted fields with weeds are more attractive to cutworm moths as a site on which to deposit their eggs.

Currently, three options are available for cutworm control: preplant or planting-time applications of soil insecticides to prevent damage and rescue treatments after the infestation appears. All have limitations.

Because of the uncertainty in predicting which fields will have light, moderate, or heavy infestations of cutworms, it may be more feasible to use rescue treatments for cutworm outbreaks rather than to use a preplant or planting-time treatment unnecessarily.

Based on the relatively low incidence of cutworm problems over the past 25 years, a grower may find an economic advantage to the wait-and-see system, which involves field scouting, rather than a costly always-apply program in which the soil insecticide is routinely applied at or before planting for a problem that may not exist.

Rescue (or emergency) treatments to control outbreaks of cutworms include sprays of chlorpyrifos (Lorsban), fenvalerate (Pydrin), carbaryl (Sevin), or trichlorfon (Dylox), or carbaryl pelletized bait. Broadcast the pelletized bait on the surface, but do not incorporate. Chlorpyrifos and fenvalerate sprays should also be broadcast. Sprays of carbaryl may be banded over the row or broadcast, but the rates need to be increased if the sprays are broadcast. Trichlorfon sprays should be banded.

The keys to effective cutworm control with the rescue treatments are the amount of surface moisture and the movement of the worms. Control may be poor, regardless of the insecticide used, if the topsoil is dry and crusted and the worms are working below the soil surface. When the soil is dry, the high rate of chlorpyrifos or fenvalerate is recommended.

To determine the need for rescue treatments, scout the fields during plant emergence, particularly those fields considered to be high-risk. **Early detection of leaf-feeding or of cutting by cutworms is vital.** When the corn plants are beginning to emerge, check the fields for leaf-feeding, cutting, wilting, or missing plants. Small cutworm larvae (less than ½ inch) feed on the leaves and do not begin cutting plants until they are about half grown.

A control measure is needed on corn in the 2-leaf stage if 3 percent or more of the plants are cut and if there are 2 or more cutworms per 100 plants. At the 4-leaf stage, control is justified if 3 percent or more of the plants are cut and if there are 4 or more worms per 100 plants. A single cutworm will cut fewer of the 4-leaf plants than those in the 2-leaf stage.

Planting-time treatments of chlorpyrifos (Lorsban 15G), ethoprop (Mocap 10G), and fonofos (Dyfonate 20G) are registered for the control of cutworms in corn. The Mocap label states that Mocap will "control light to moderate infestations of black and sandhill cutworms"; Dyfonate is labeled for "suppression of black cutworms." Some growers may want to use one of these products in fields with a history of cutworm problems or in high-risk fields. Lorsban has provided the best cutworm control in research trials during the past few years. Research also indicates that planting-time treatments are relatively effective in controlling light to moderate infestations, but control may be unsatisfactory for heavy infestations.

Preplant broadcast treatments of chlorpyrifos (Lorsban 4E) and fonofos (Dyfonate 4E) are also registered for corn cutworm control. Lorsban is labeled at rates of 1 to 2 quarts per acre; the higher rate is suggested. Dyfonate is labeled for "suppression of black cutworms" at 4 quarts per acre. Both insecticides should be incorporated into the top 2 to 4 inches of soil immediately after application.

Replanting may be required if cutworm damage is extremely severe. Before replanting apply chlorpyrifos (Lorsban 4E) as a broadcast spray at 3 to 4 pints per acre, and incorporate the insecticide into the top 2 to 4 inches of soil. Or you can apply a granular insecticide (Lorsban 15G, Mocap 10G, Dyfonate 20G). If the cutworm infestation is heavy, the Lorsban spray will be more effective.

WIREWORMS

Wireworms may attack the seed or drill into the base of the stem below ground level, damaging or killing the growing point. Damage will show up as wilted, dead, or weakened plants and spotty stands. Wireworm larvae are yellowish-brown and wirelike; several species are known to attack corn. They live for two to five years in a field in the larval stage, feeding on the roots of grasses and crops. There is often a relationship between crops that were in the field two to four years before damage to the corn. Most reports of damage to corn have been in fields where corn follows soybeans or where there has been a corn-soybean-small-grain rotation.

The adult (a click beetle) prefers to deposit its eggs in small-grain stubble or in grassy fields. Attempts to control wireworms with an insecticide rescue treatment after the damage appears are not very successful. Therefore, if an infestation is known to be present, insecticides must be applied at planting.

Wireworms are usually most damaging in bottomlands or in poorly drained areas on upland soils. Low spots in the field often have the heaviest populations.

The proportion of fields of corn affected by wireworms in Illinois is small (less than 1 percent) and does not justify the widespread use of a soil insecticide on first-year corn after soybeans. A diazinon + lindane planter-box seed treatment at planting may help deter the wireworms from attacking the seed but will not protect the seedling.

Checking for Wireworms

A technique using baits has been developed for evaluating wireworm potential before planting. The bait stations should be established 2 to 3 weeks before the anticipated planting date. Fields where small grain or grasses have been grown the preceding 2 or 3 years are the best candidates for bait stations.

Since wireworm infestations are often localized within a field, it will be necessary to place the bait stations randomly throughout the field. One bait station per acre is desirable. As a minimum, place 2 stations at the highest elevation in a field, 2 on a slope, and 2 in the lowest area.

Follow this procedure for baiting:

1. Use a mixture of 1 cup of untreated wheat and 1 cup of untreated shelled corn at each station.
2. Bury the bait about 4 inches deep. It is also desirable to cover the ground over each bait station with an 18-inch square of black plastic. The plastic collects solar heat and speeds germination of the corn and wheat, which entices overwintering wireworms.
3. Mark each station with a flag or stake.
4. Dig up the bait stations in 10 to 14 days and count the number of wireworms.

Need for Treatment

If you find an average of one wireworm per bait station, use a labeled soil insecticide. In some instances, several wireworms may be found in one bait station and none in others. Wireworm infestations tend to concentrate in some locations. It may be possible to limit treatment to areas where the concentration is heaviest.

WHITE GRUBS

Several species of economically important white grubs have 3-year life cycles. Peak years of damage usually occur during the year following large flights of May beetles, the adult stage of white grubs. The beetles prefer to lay their eggs in ground covered with vegetation, such as weedy soybean fields and sod.

The C-shaped white grub larvae chew on the roots and root hairs of corn seedlings. During peak years of damage, the grubs feed all season long. Damage to a cornfield is most apparent in the spring. Symptoms of white grub injury visible aboveground are irregular emergence, reduced stands, and stunted or wilted plants. The damage is usually spotty throughout the field.

There are no effective rescue treatments for white grubs after the damage appears. However, if plants show symptoms of injury, dig around the root system of several corn plants. If white grubs are causing the problem and replanting is warranted, apply terbufos (Counter 15G), chlorpyrifos (Lorsban 15G, 4E), or isofenphos (Amaze 20G, 6E) at the labeled rates.

PLANTER-BOX SEED TREATMENTS

Corn. A planter-box seed treatment with diazinon will protect germinating corn against attack by seedcorn beetles and maggots. Chlorpyrifos (Lorsban 50-SL) is labeled as a slurry treatment on seed before planting to protect germinating seed against injury by seedcorn maggots and beetles. A diazinon + lindane planter-box seed treatment protects seed from wireworms but will not protect seedlings. Use a seed treatment in fields that do not receive a soil insecticide at planting time. NOTE: Excess dust from the seed treater may interfere with the electronic monitor in air planters.

Soybeans. Use a diazinon seed protectant to prevent damage to germinating soybeans from seedcorn maggots. Follow the label directions for application. The potential for damage is greatest during cool, wet springs when germination is slow.

EUROPEAN CORN BORERS

Corn borer moths begin to emerge in late May in southern Illinois and mid- to late June in the central and northern regions. The females lay most of their eggs in the evening. They spend the daylight hours in fencerows and other protected areas.

First-generation borers reduce yields by stalk-tunneling, which weakens the plant and destroys the tissue used to transport food within the plant.

Corn that is planted early (the fields with the tallest corn) should be monitored closely for signs of whorl-feeding by corn borer larvae from mid-June to early July. The fields with the tallest corn are the most attractive for egg laying by first-brood moths. Control is warranted if 50 percent or more of the plants have fresh whorl-feeding, if live borers are present, and if plants are 24 or more inches tall (with the leaves extended). Seed production fields should be treated when 15 to 25 percent of the plants have whorl feeding and larvae are present.

Corn hybrids have varying degrees of tolerance or resistance to leaf-feeding by first-generation borers. Consider this trait when selecting varieties for 1983.

Corn planted late is most attractive to moths laying eggs for the *second generation.* Yield losses caused by second-generation borers are a result of stalk breakage and ear drop, as well as physiological damage. Corn-borer entrance holes also provide avenues for stalk rot organisms. Monitor fields from mid-July to mid-August for egg masses or newly hatched larvae of the second brood.

To assess the potential for second-generation corn borer, start checking for egg masses when moth flight is underway. Examine a minimum of 25 plants, selected at random throughout the entire field, and count the number of egg masses that are found on each plant. Although the moths usually lay their eggs on the two or three leaves above or below the developing ear, you should check all the leaves. One technique is to remove the leaves one by one, starting at the bottom of the plant, and carefully scan them for egg masses.

The eggs, which are deposited in masses of 15 to 30, overlap like the scales of a fish. Calm nights favor egg deposition by the moths. The absence of hard, beating rains during moth emergence also increases the potential for infestations.

Egg masses are flat and about half the size of your little fingernail. Newly deposited eggs are white, then turn pale yellow, and become darker just before hatching. Eggs that are about to hatch have distinct black centers. These are the black heads of the larvae that are visible through the translucent eggshell. The eggs hatch in 3 to 7 days, depending on the temperature. The female moth hides in grass and weeds during the day. Noncrop areas that border cornfields may harbor large numbers of corn borer moths during the day. Check these areas for moths as you enter the field to determine the amount of corn borer infestation.

Treatment is warranted when you find 1 egg mass for every two plants. Because peak egg laying generally occurs over a period of 2 to 4 weeks, it will be necessary to resample fields if egg masses are not present on half of the plants during the initial survey. If cumulative counts (taken 1 week apart) exceed 1 egg mass for every two plants, apply a treatment.

For best results, treatment should be applied soon after egg hatch to kill the young larvae before they bore into the plant. The larvae begin tunneling into the stalks about 10 days after hatching. Because egglaying for the second generation extends over a 3- to 4-week period, timing of insecticide application should be precise. Occasionally, two treatments may be necessary for satisfactory control.

CORN LEAF APHIDS

Corn leaf aphids are small, soft-bodied, greenish-blue plant lice about the size of a pinhead. They do not overwinter in Illinois. Winged corn leaf aphids, blown into Illinois on southwesterly winds during mid- to late June, become established within the whorl leaves of the corn plant. These aphids give birth to living young. In the absence of predators, parasites, diseases, and hard beating rains, aphid populations may increase very rapidly.

Corn leaf aphids cause damage by sucking moisture from the corn plant. Soil moisture stress and heavy infestations on the upper leaves and tassel may result in barren plants or reduced ear size. The critical period for damage is during tassel emergence through pollination. If aphids are allowed to cover the tassel and upper two or three leaves, yield losses are likely to occur.

Fields should be scouted for aphids beginning about one week before tassel emergence. Pull and unroll the whorl leaves of plants selected at random to check for aphids. Treatment is suggested if 50 percent of the plants have 100 or more corn leaf aphids per plant during tassel emergence and if *plants are under drouth stress.* Aphid populations usually decline after pollination is complete. However, treatment may be warranted following pollination if aphid populations continue to cover the tassel and one or two of the upper leaves.

REDUCED TILLAGE AND NO-TILL INSECT PESTS

Concern about insect problems should not keep growers from adopting conservation tillage practices. The soil-insect complex in corn, which is similar in many ways for conventional and reduced-tillage systems, can be readily controlled by applying soil insecticides at planting time. With a few exceptions, outbreaks of insects feeding on foliage can be controlled with properly timed treatments of insecticides. **Close monitoring of fields to detect insect outbreaks is very important, regardless of the tillage system.**

Weather conditions and the type of crop rotations determine to a great extent whether a soil insect problem will occur and what kind it will be. In some instances, tillage may also influence the kind and abundance of an insect pest. Some tillage operations favor specific pests. Others tend to reduce pest problems. The general expectation is that insect infestations will be more pronounced where no-tillage is used in corn than where conventional or reduced-tillage systems are used.

No-Till Pests

Insect problems occur more frequently in no-till corn than in any other conservation tillage system and are often more serious. Crop residue left by the use of no-till practices provides a stable environment for pest survival and development. Pest problems occurring under these conditions include European corn borer, cutworms, armyworm, common stalk borer, wireworms, seedcorn maggots, billbugs, slugs, and mice. Soil insecticides may be needed on no-till corn following corn (in rootworm area), grass sod, legumes, or following any crop in which grasses and broadleaf weeds are prevalent.

Soil Insect Control

Select a soil insecticide that will control the anticipated soil insect pest. Consult Table 4 for suggestions. If a soil insecticide is not applied at planting, a diazinon planter-box seed protectant will give protection against seedcorn maggots and seedcorn beetles.

Surface residues from no-till and reduced-tillage systems may present some problems with the placement and incorporation of granular soil insecticides applied at planting. To be most effective, the soil insecticide should be incorporated into the upper ½ inch of soil, and not just broadcast on the surface. Granules remaining on the soil surface are degraded by sunlight, resulting in erratic or poor control.

NOTE: Before using Mocap, Dyfonate, or Thimet on no-till corn, be sure that soil moisture is low enough to ensure closing of the seed furrow to prevent the insecticide granules from contacting the seed. Crop injury may occur with these products.

Aboveground Insect Pests

Aboveground insects will be more of a problem in no-till corn than under reduced or conventional tillage. Corn planted in grass sod or fall-seeded rye is vulnerable to attack by *armyworms*. The moths lay eggs on the grasses during April or early May. After vegetation is killed by a herbicide, the larvae move to the young corn seedlings and feed on them. Control is justified when 25 percent of the plants are being damaged. Rescue treatments are effective, but a spray volume of 15 to 20 gallons per acre will improve coverage and control.

Instances of damage to corn by the *common stalk borer* have been greater in no-till corn than with other tillage systems. Moths of this insect deposit their eggs on weeds in late August and September. When a herbicide is applied in the spring to no-till corn in fields previously infested with host weeds, the newly hatched stalk borer larvae move from the dead vegetation and attack newly emerging corn plants. Postemergence treatments generally give poor control of common stalk borer because the chemicals cannot reach the worms inside the stem. To reduce the potential of stalk borer damage in a subsequent season, it is essential to practice good weed control within a field during August and September, when moths are laying eggs.

Noninsect pests in no-till corn include *slugs* and *mice*. There are no effective control measures for slugs. Mouse damage may be a severe problem, particularly in corn following sod. To reduce or prevent mouse damage to corn, use a hopper-box seed treatment of methiocarb (Mesurol 50% bird repellent) at the rate of 1 pound per 100 pounds of seed corn. This product has a state label.

FORAGE INSECTS

In 1983, we expect *alfalfa weevils* to cause moderate to severe damage to the first cutting of alfalfa in most areas of Illinois. In the southern counties, where a lot of egg laying takes place in the fall, alfalfa-weevil larval damage occurs early in the spring. Damage to the first cutting in northern Illinois is more likely to occur if hay harvest is delayed. Otherwise, the injury to alfalfa in the northern counties will occur on the stubble and new growth of the second cutting.

Numbers of alfalfa weevils are regulated to a large extent by winter weather. During a cold, open winter the mortality rate is high in overwintering weevil populations; during mild winters the mortality rate is low.

A parasitic wasp and a fungal disease organism that attacks alfalfa weevil larvae sometimes regulate weevil numbers in the spring. Although the wasp and the fungus will be present in alfalfa fields in 1983, we cannot yet predict their effect on weevil numbers.

Alfalfa growers in southern and central Illinois should inspect their fields closely in April, May, and June. Early larval damage appears as pinholes in the growing terminals. As the larvae grow, they skeletonize the leaves, and damaged fields appear tattered. Growers in northern Illinois should look carefully for larval damage in late May and June. All growers should examine the stubble after the first cutting, because larval and adult feeding can slow or halt new growth. Follow the suggestions in Circular 1136, "Alfalfa Weevil Pest Management Program," to determine the need and proper timing of a treatment. If this circular is unavailable, a rule of thumb is to treat when 25 percent of the tips are being skeletonized. This threshold may be as high as 40 percent in northern Illinois, where damage occurs later in the season.

Potato leafhoppers may cause moderate to severe damage to the second and third cuttings of alfalfa in all areas of Illinois in 1983. Populations of leafhoppers were large in 1982, and many acres of alfalfa were injured severely. Damaged alfalfa was stunted and turned yellow or brown. Many people confused the damage with diseases or nutrient deficiency.

Damage first appears as a yellow, wedge-shaped area at the tip of the leaf and is more evident during dry weather. However, population levels are difficult to predict because the leafhoppers do not survive the winter in Illinois. They migrate from southern states into Illinois during May and June.

Potato-leafhopper damage may begin on the new growth as soon as the first hay crop is removed. (Stunting and yellowing are signs of leafhopper injury.) A swarm of leafhoppers at the time of the first cutting indicates that there may be a problem in the new growth. The economic threshold for potato leafhoppers varies with the height of the alfalfa (see Table 4). A treatment is justified when the number of leafhoppers exceeds the economic threshold.

Table 4. Economic Thresholds for Potato Leafhoppers on Alfalfa

Alfalfa height (inches)	Average number of leafhoppers per sweep of sweep net
0-3	0.2
3-6	0.5
6-12	1.0
12 or taller	1.5

BEAN LEAF BEETLES

Bean leaf beetles overwinter as adults under debris in fencerows, wooded areas, and other protected sites. The survival of the overwintering beetles depends on the winter weather. A mild winter increases the chances for a large population in the spring. In addition, if soybeans are planted early in 1983, the beetles will establish themselves early. The availability of soybeans during the early part of the season is essential for the survival of bean leaf beetles. The survival of large numbers early in the season generally means an even larger population in August. On the other hand, a severe winter and later planted soybeans will reduce the number of bean leaf beetles in the spring.

The beetles may cause considerable leaf-feeding injury to double-cropped soybeans and late maturing soybean varieties. Insecticide treatments are recommended during the critical pod-set and pod-fill stages, when defoliation exceeds 20 percent. The greatest concern, however, is caused by the beetles' pod-feeding damage, which leaves scars on many pods. These scars predispose the pods to fungal infections. A treatment is recommended when 10 percent of the pods are damaged.

CHEMICAL INJURY TO SOYBEANS

There have been instances of phytotoxicity to soybeans when organic phosphate soil insecticides were used. The problems have occurred where growers started planting soybeans without first emptying the insecticide boxes. Organic phosphate soil insecticides applied in soybean fields treated with metribuzin (Sencor or Lexone) may result in injury to a soybean crop, according to information on the labels.

CALIBRATION FOR GRANULAR SOIL INSECTICIDES

Calibrate the applicators for granular soil insecticides before the planting season begins. In some instances, poor control is caused by applying rates that are too low. Proper calibration will help avoid this problem. Most soil insecticide bags have a list of suggested settings for the particular model of applicator. The settings are based on planting speed. The *beginning settings* are helpful, but be sure to check your actual application rate under your own operating conditions.

Follow these steps for calibrating the applicator:

1. Calibration of granular applicators for soil insecticides is usually based on determining how many ounces of product are needed per 1,000 feet of row. Consult the insecticide label or Table 2 for labeled rates for rootworm control. These rates are expressed in ounces per 1,000 feet of row and pounds of product per acre.
2. Consult the label or manufacturer's recommendation for an approximate application setting. Adjust the setting on each hopper.
3. Select an area for a test run, preferably in the field, so that speed and traction conditions are constant. Measure off 1,000 feet.
4. Fill the hoppers and attach a plastic bag or container to each delivery tube to catch the granules from each hopper.
5. Drive the premeasured distance (1,000 feet) at the same speed to be used during the planting operation.
6. Weigh the material collected from each hopper. Use a scale that weighs in ounces (e.g., a postal scale or a diet scale).
7. Compare the quantity (ounces) per bag against those given in Table 2. To obtain one pound of active ingredient per acre the following amounts of material should be collected:

Formulation, percent	Oz. collected per 1,000 ft.
10	12
15	8
20	6

8. Recalibrate if the difference in quantity applied during the calibration process is more than 10 percent over or under the rate suggested on the label.

MANAGING INSECT PESTS IN STORED GRAIN

This section describes a program for preventing insect problems in stored grain. For more details on insecticide formulations and dilution of them, see Table 11.

Store only clean, dry grain. Its moisture content should be 13 percent or less; it should be cooled to 40°F as soon as possible; and foreign material should be kept to a minimum. If grain is to be stored one month or more between May and October, follow the procedures listed below.

Wheat

1. Thoroughly clean in, around, and under the bin and clean grain-handling equipment before harvest. Collect the first few bushels coming through the combine and feed to livestock.
2. Spray the walls, ceiling, and floor of the bin to runoff with 1.5 percent malathion; use 3 ounces of the 50 to 57 percent EC per gallon of water.
3. Treat the wheat with malathion. Mix 1 pint of malathion 50 to 57 percent EC in 2 to 5 gallons of water and spray the mixture as uniformly as possible over each 1,000 bushels. Treat the wheat as it is being augered or elevated into the bin. An alternative is to apply 10 pounds of 6 percent malathion dust (wheat flour) per 1,000 bushels. Do not treat the grain until after it is heat dried.
4. Hang one dichlorvos resin strip per 1,000 cubic feet of overspace in enclosed bins and replace the strips every 6 weeks. In open bins use the dichlorvos resin strips under a raised tarp. An alternative to the dichlorvos strip is *Bacillus thuringiensis* (Dipel, Topside, SOK-BT). Apply it as a wettable powder (1 pound per 10 gallons of water) or liquid concentrate (4 pints per 10 gallons of water) at 0.6 pints per bushel to the top 4 inches of wheat as it is augered into the bin. A dust formulation of *Bacillus thuringiensis* is available and should be applied at ½ ounce per bushel on the top 4 inches of wheat as it is binned. Level the surface of the wheat after treatment.

The *Bacillus thuringiensis* can also be applied after the wheat is binned. Apply one-third of the dosage over the entire surface and rake it in with a garden rake to a depth of 4 inches. Follow the same procedure for the second one-third of the dosage, and rake at a 90° angle to the first raking. Apply the last one-third over the surface and leave it undisturbed. The dichlorvos resin strip and the *Bacillus thuringiensis* treatments are to be used for Indian meal moths that are resistant to malathion.

5. Spray the surface of the grain with malathion. Add 3 ounces of malathion 50 to 57 percent EC to 1 gallon of water. Apply at a rate of 2 gallons of finished spray per 1,000 square feet. An alternative is to apply 6 percent malathion dust at 5 pounds per 1,000 square feet. The surface treatment will help prevent infestation by insects entering bins through the top vent.

6. Cool the grain to 40°F as soon as possible. Insect reproduction ceases below 60°F, and feeding stops below 50°F.

7. Reinspect the grain at regular monthly intervals. Insert metal rods or a temperature probe down through the center of the grain to check for "hot spots."

Shelled Corn

Follow the same steps as for wheat if the corn is harvested before October 1 or carried over beyond May 15 of the following year. Otherwise, no treatment is needed other than cleanup and bin spraying.

Sorghum

Follow the same steps as for shelled corn.

Soybeans

Clean the bin and grain-handling equipment before harvest, and spray the walls, ceiling, and floor of the bin as suggested for wheat. If soybeans are harvested before October 1 or carried over beyond May 15 of the following year, follow step 4 under wheat. Aluminum phosphide can be used to fumigate soybeans.

Sunflowers

Follow the same steps as for soybeans.

Infested Grain

Apply a fumigant to corn or wheat that becomes infested between May and October, following the procedure described below. After fumigating, follow steps 4 through 7 under wheat. If the problem is *only* with Indian meal moth, see alternate suggestions in step 7.

NOTE: Bins with a capacity of more than 3,000 bushels should probably be treated by a licensed, professional fumigator. See your county Extension adviser in agriculture for a list of licensed fumigators.

1. On a calm, warm day when the grain temperature is above 65°F (preferably above 70°F), seal cracks and holes in the bin, paying particular attention to the base area around the doors and ventilating fan.

2. Level the surface of the grain, break up any caked or crusted areas, and remove webbing. The surface level of the grain should be at least 8 inches below the lip of the bin.

3. Apply a liquid fumigant at 3 to 5 gallons per 1,000 bushels. Use the higher rate on wooden bins and in flat storages. Place the containers on the surface, spacing them evenly. Loosen the caps slightly, then remove them, and invert the containers on the surface. *Get out of the bin within 30 seconds to one minute.* It is better to apply the liquid fumigant uniformly over the surface as a course spray if you can do so from outside the bin. Have someone standing outside the bin as a safeguard. Some common liquid fumigants are carbon bisulfide + carbon tetrachloride (80:20 mixture), and ethylene dichloride + carbon tetrachloride (75:25 mixture). Other liquid fumigants may contain additional materials such as ethylene dibromide and sulfur dioxide and are also effective. A dry fumigant called aluminum phosphide (Phostoxin, Detia) may be used in place of the liquid fumigants. A special applicator is required to place the tablets or pellets in the grain mass. When handling the tablets, do not allow water to come in contact with them. Wear neoprene rubber gloves to prevent perspiration from touching the tablets.

4. Put a tarp over wooden bins if you can do so safely. Close for 72 hours and then air out. The empty containers should be removed from the bin after airing and disposed of properly.

5. Place signs at all entrances warning that the bin is being fumigated and list the fumigant used and the name, address, and telephone number of a responsible person to contact in case of emergency.

6. As an alternative to fumigation, it may be possible to use a malathion protectant treatment. If the grain can be moved to a clean and sprayed bin, apply a spray of malathion to the grain as it is augered or elevated to the new bin. The spray is commonly applied from a 3-gallon tank sprayer. Mix 1 pint of 50 to 57 percent malathion in 2 to 5 gallons of water and spray the mixture on each 1,000 bushels. Although the malathion will not immediately kill insects that are inside the kernels, it will eventually provide effective control.

NOTE: Anhydrous ammonia is not suggested for fumigation of stored grains. It is generally ineffective against insects in stored grain at dosages below the point at which grain is blackened from exposure. Fumigation should be used if the grain is to be marketed immediately. Screen the fumigated grain *before shipping.*

7. If the problem is only with Indian meal moth, an alternative to fumigation is to use both the *Bacillus thuringiensis* and dichlorvos resin strip treatments as suggested in step 4 under wheat.

Uninfested Carry-Over Grain

Beginning about May 15 in the southern half of Illinois and June 1 in the northern half of the state, follow these suggestions. Grain not treated with an overall malathion protectant spray will need to be fumigated in the summer. Normally, in the southern half of Illinois, two fumigations per season will be needed. Apply the first treatment in mid-July and the second about September 1. In the northern half of the state, one fumigation per season is usually sufficient. Apply this treatment in mid-August. In addition, follow steps 4 through 7 under wheat. Follow the same procedure for each succeeding year of storage.

Table 5. Field Corn

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Corn rootworm larvae	June-July	**Amaze (isofenphos) Counter (terbufos) **Dyfonate (fonofos) **Dyfonate (fonofos) **Furadan (carbofuran) Lorsban (chlorpyrifos) **Mocap (ethoprop) Thimet (phorate)	1[b] 1[b] 1[b] 3 1[b] 1[b] 1[b] 1[b]	Band Band Band Broadcast-PPI[c] Band Band Band Band	For John Deere 7000 series planters, place Dyfonate, Mocap, and Thimet behind the firming wheels. Do not place Dyfonate, Mocap, or Thimet in direct contact with the seed. Basal treatments during cultivation with Amaze, Counter, Dyfonate, Furadan, Lorsban, Mocap, or Thimet are effective in late May or early June.
Seedcorn maggot	At germination	**Amaze (isofenphos) Counter (terbufos) **Dyfonate (fonofos) Lorsban (chlorpyrifos)	1[b] 1[b] 1[b] 1[b]	Band Furrow Band Furrow	At planting.
		diazinon diazinon + lindane Lorsban (chlorpyrifos)	See label See label See label	On seed On seed On seed	Use formulations that are prepared as seed treaters. Seed treatments should be considered for fields that do not receive a soil insecticide at planting.
Seedcorn beetles	At germination	**Amaze (isofenphos) **Dyfonate (fonofos) Lorsban (chlorpyrifos) Thimet (phorate)	1[b] 1[b] 1[b] 1[b]	Band Band Furrow Band	At planting.
		diazinon Lorsban (chlorpyrifos)	See label	On seed	Use formulations that are prepared as seed treaters.
Wireworms	May-June	Counter (terbufos) **Dyfonate (fonofos) **Furadan granules (carbofuran) Lorsban (chlorpyrifos) Lorsban (chlorpyrifos) **Mocap (ethoprop)	1[b] 4 2[b] 2[b] 2 1[b]	Band, furrow Broadcast-PPI[c] Band, furrow Furrow Broadcast-PPI[c] Band	Amaze is labeled for control of low to moderate infestations. Thimet and Dyfonate applied in a 7-inch band are labeled for suppression of wireworms.
Cutworms	May-June	Lorsban granules (chlorpyrifos) Lorsban spray (chlorpyrifos)	1[b] 1-2	Band Broadcast-PPI[c]	At planting. Planting-time applications of Mocap 10G will control light to moderate infestations of black and sandhill cutworms. Dyfonate 20G applied at planting time will suppress black cutworms.
		Lorsban spray (chlorpyrifos) Sevin spray (carbaryl) Sevin bait (carbaryl) Dylox, Proxol spray (trichlorfon) *Pydrin spray (fenvalerate)[d]	1-1½ 2[b] 1-2 1[b] 0.1-0.2	Broadcast Plant base Broadcast Plant base Broadcast	Apply as a postemergence rescue treatment when 3 percent or more of the plants are cut in the 2-leaf stage and there are 2 or more cutworms per 100 plants. At the 4-leaf stage, control is justified if 3 percent or more of the plants are cut and there are 4 or more worms per 100 plants.
White grubs	May-October	**Amaze (isofenphos) Counter (terbufos) Lorsban granules (chlorpyrifos) Lorsban spray (chlorpyrifos)	1[b] 2[b] 1-2[b] 2	Band Band Furrow Broadcast-PPI[c]	Amaze is labeled for control of low to moderate infestations, and Counter is labeled for reduction of white grubs at planting.

Table 5. Field Corn (continued)

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Garden symphylan	May-July	Counter (terbufos)	1-2[b]	Band	At planting.
		**Dyfonate (fonofos)	2	Broadcast-PPI[c]	
		Lorsban granules (chlorpyrifos)	1-1½[b]	Band	
		Lorsban spray (chlorpyrifos)	1-2	Broadcast-PPI[c]	
Billbug	May-June	Lorsban granules (chlorpyrifos)	1-2[b]	Band	
		Lorsban spray (chlorpyrifos)	2	Broadcast-PPI[c]	
		Lorsban spray (chlorpyrifos)	1-1½	Broadcast	Apply Lorsban spray as a postemergence rescue treatment when damage appears. Apply Counter granules over the row of seedling corn plants and incorporate. Apply rescue treatments with ground equipment.
		Counter granules (terbufos)[d]	1½-2[b]	Over row	
Flea beetles	May-June	Sevin, Savit (carbaryl)	1[b]	Over row as spray	When leaves on seedling plants are severely damaged and some plants are being killed.
		diazinon	½[b]		
		Lorsban (chlorpyrifos)	1-1½[b]		
		*Lannate (methomyl)[d]	¼-½[b]		
		*Penncap-M (microencapsulated methyl parathion)	½-¾		
Sod webworm	May-June	None labeled		At base of plant	At time of initial attack, sprays of carbaryl or chlorpyrifos may be effective.
Common stalk borer	May-June	Furadan granules (carbofuran)	2-3[b]	Band, furrow	Application of Furadan at planting time may provide early season suppression of common stalk borers. Postemergence sprays of fenvalerate (Pydrin), carbaryl (Sevin), methomyl (Nudrin, Lannate), or chlorpyrifos (Lorsban) may give some control if applied when damage first appears.
Hop vine borer	May-June	None labeled	..	...	Postemergence sprays of fenvalerate (Pydrin), carbaryl (Sevin), methomyl (Nudrin, Lannate), or chlorpyrifos (Lorsban) may give some control if applied when damage first appears.
Thrips	May-June	malathion	1[b]	On foliage as spray	When severe wilting and yellowing of leaves are noticed.
Armyworms	May-August	Furadan granules (carbofuran)	1	Band, furrow	Apply Furadan 15G as a planting-time treatment for armyworms in corn planted no-till in grass sod or small grains.
		Sevin (carbaryl)	1½	Over row as spray	At first migration, or when worms are eating leaves above ear level.
		Dylox, Proxol (trichlorfon)	1		
		*Lannate, *Nudrin (methomyl)[d]	½		
		malathion	1		
		Lorsban (chlorpyrifos)	1		
		*Penncap-M (microencapsulated methyl parathion)	½-¾		
Chinch bug	June-August	Sevin (carbaryl)†	2[b]	Spray at base of plant	At start of migration from small grains. Use only ground equipment and apply 25 to 40 gallons per acre.
		Lorsban (chlorpyrifos)	½-1[b]		
European corn borer, first generation	June-July	diazinon granules	1	On upper ⅓ of plant and into whorl	When 50% or more of the plants have fresh whorl feeding, live borers present, and extended leaf height is 24 inches or greater.
		Furadan granules (carbofuran)	1		
		Dyfonate granules (fonofos)	1		
		Lorsban (chlorpyrifos)	1		
		*Penncap-M (microencapsulated methyl parathion)	1		
		*Pydrin (fenvalerate)[d]	0.1-0.2		

Table 5. Field Corn (continued)

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
European corn borer, second generation	Late July, mid-August	diazinon granules Furadan granules (carbofuran) Dyfonate granules (fonofos) Lorsban (chlorpyrifos) *Penncap-M (microencapsulated methyl parathion) *Pydrin (fenvalerate)[d]	1 1 1 1 1 0.1-0.2	On foliage	Apply at first hatch when half of the plants have egg masses, or when cumulative counts, made one week apart, exceed 1 egg mass for every 2 plants.
Woollybear caterpillars	July	None labeled	..	...	Silk clipping caused by caterpillars does not generally warrant control.
Grasshoppers	June-September	Sevin (carbaryl) diazinon Cygon (dimethoate)[d] malathion Lorsban (chlorpyrifos) *Penncap-M (microencapsulated methyl parathion)	1-1½ ½ ½ 1 ¼-½ ½	Over row as spray	As needed.
Spider mites	July-August	Di-Syston granules (disulfoton)[d] Thimet granules (phorate)[d] ethion[d] diazinon	1 1 1 ½	On foliage	Begin control if the majority of plants are infested with mites severe enough to cause some yellowing or browning of the lower leaves before dent stage.
Japanese beetle	July-August	Sevin, Savit (carbaryl)	1	Over plant	During the silking period to protect pollination if less than 75% of plants are silked and three or more beetles are present per ear.
Corn leaf aphid	July-August	malathion diazinon Lorsban (chlorpyrifos) *Lannate (methomyl)[d] *Penncap-M (microencapsulated methyl parathion)	1 1 ½ ¼ ½-¾	On foliage	Apply during late whorl to early tassel when 50% of plants have light to moderate infestations and plants are under drouth stress.
Corn rootworm beetles	July-August	Sevin, Savit (carbaryl) malathion diazinon *Lannate (methomyl)[d] *Penncap-M (microencapsulated methyl parathion)	1 1 ½ ¼-½ ½	Overall spray or directed toward ear zone	Before 75% of plants have silked, if there are 5 or more beetles per plant and if silk clipping is observed. Only to protect pollination. Imidan is labeled for suppression of corn rootworm beetles.
Southwestern corn borer	August	Furadan granules (carbofuran) diazinon granules Dyfonate granules (fonofos) Lorsban (chlorpyrifos) *Penncap-M (microencapsulated methyl parathion) *Pydrin (fenvalerate)[d]	1 1-2 1 1 1 0.1-0.2	On foliage	Direct granules over row. Apply when 25% of the plants have egg masses or larvae on leaves. Early-planted corn usually escapes damage.
Picnic, sap beetles	July-August	*Lannate (methomyl)[d] Sevin (carbaryl)	¼-½ 1	On foliage	Justified only in seed corn fields.
Corn earworm	August	Sevin (carbaryl) *Lannate, *Nudrin (methomyl)[d] *Pydrin (fenvalerate)[d]	2 ½ 0.1-0.2	Over row	Justified only in seed corn fields. Insecticide applications are rarely effective for the control of earworms in commercial field corn after worms enter ear tips.

Table 5. Field Corn (continued)

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Fall armyworm	July-September	Sevin, Savit sprays (carbaryl)	2	On foliage	Treat when 35% of plants have whorl damage and if worms are present. Ground sprays directed over the row are more effective than broadcast sprays. Treatments to control worms in ear tips are not effective.
		Dylox, Proxol spray (trichlorfon)	1		
		*Lannate, *Nudrin (methomyl)[d]	½		
		Lorsban (chlorpyrifos)	1		

* Use restricted to certified applicators only.
** Liquid formulations of Dyfonate, Furadan, Mocap, and Amaze are restricted. Amaze 20G is also restricted.
† State labeled insecticide. Applicator must have Illinois label in possession when applying.
[a] See Table 15 for insecticide restrictions.
[b] Based on 40-inch row spacing. Increase rates for narrow rows.
[c] PPI Pre-plant incorporated.
[d] To be applied only by experienced operators or those wearing protective clothing.

Table 6. Soybeans

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Seedcorn maggot	Germination	diazinon	See label	On seed	At planting time. Use formulations that are prepared as seed treaters.
Bean leaf beetle	May-June, August	Sevin, Savit (carbaryl)	1	On foliage	Before bloom: when defoliation reaches 30%, at least 1 cotyledon per foot of row is destroyed, and there are 5 or more beetles per foot of row. Bloom to pod fill: when defoliation reaches 20% and there are 16 or more beetles per foot of row. Seed maturation: when 10% of the pods are damaged, the leaves are green, and there are 10 or more beetles per foot of row.
		Orthene (acephate)	½-1		
		*Penncap-M (microencapsulated methyl parathion)[b]	1		
		*Lannate, *Nudrin (methomyl)[c]	½		
		Lorsban (chlorpyrifos)	½-1		
		*Pydrin (fenvalerate)[c]	0.1		
Cutworms	May-June	Sevin bait (carbaryl)	1-2	Broadcast	During plant emergence if stand has gaps of one foot or more and cutworms are present.
		Sevin spray (carbaryl)	1-1½	Band	
		Lorsban (chlorpyrifos)	1	Broadcast	
Thistle caterpillar	June	Sevin (carbaryl)	2	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Mexican bean beetle	May-July	*Penncap-M (microencapsulated methyl parathion)[b]	½-¾	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
		Orthene (acephate)	½-1		
		*Lannate, *Nudrin (methomyl)[c]	½		
		Sevin (carbaryl)	1		
		malathion	1½		
		Cygon (dimethoate)[c]	½		
		*Pydrin (fenvalerate)[c]	0.05-0.1		
		Lorsban (chlorpyrifos)	½-¾		
Grasshoppers	June-September	Cygon (dimethoate)[c]	½	On foliage	When migration into fields begins and defoliation or pod feeding reaches economic levels. When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
		Sevin, Savit (carbaryl)	1		
		Orthene (acephate)	½		
Japanese beetle	June-July	Sevin (carbaryl)	1	On foliage	When defoliation reaches 20% during bloom and pod fill.
		*Penncap-M microencapsulated methyl parathion)[b]	¾-1		

Table 6. Soybeans (continued)

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Green cloverworm	July-August	Sevin (carbaryl) *Lannate, *Nudrin (methomyl)[c] Orthene (acephate) malathion Dipel, Thuricide, Bactur, SOK (*Bacillus thuringiensis*) Lorsban (chlorpyrifos) *Penncap-M (microencapsulated methyl parathion)[b] *Pydrin (fenvalerate)[c]	1 ½ ½-1 1½ See label ¼-½ ½-¾ 0.1	On foliage	When defoliation occurs during blooming, pod set, and pod fill. Usually requires 12 or more half-grown worms per foot of row and 20% defoliation to justify treatment.
Webworms	June-August	Sevin, Savit (carbaryl)	1	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Spider mite	June-August	Cygon (dimethoate)[c]	½	On foliage	As needed on field margins or entire field.
Stink bugs	July-August	Orthene (acephate) *Penncap-M (microencapsulated methyl parathion)[b] Sevin (carbaryl)	¾-1 ½-¾ 1	On foliage	When adult bugs or large nymphs reach 1 per foot of row during pod-fill.
Thrips	June-August	Sevin, Savit (carbaryl) *Lannate, *Nudrin (methomyl)[c] *Penncap-M (microencapsulated methyl parathion)[b]	1 ¼ ½-¾	On foliage	If seedlings are being seriously damaged and some plants are being killed.
Blister beetles	July-August	Sevin (carbaryl)	1	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Saltmarsh caterpillar	August	Sevin (carbaryl) *Lannate, *Nudrin (methomyl)[c]	2 ½	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Loopers	August	Orthene (acephate) Thuricide, Dipel, Bactur, SOK (*Bacillus thuringiensis*) *Lannate, *Nudrin (methomyl)[c] *Pydrin (fenvalerate)[c]	½-1 See label ½-1 0.1-0.2	On foliage	When defoliation reaches 30% before bloom and 20% between bloom and pod fill.
Woollybear caterpillar	August	None labeled	...	...	Infestations are rarely economic.
Whitefly	August-September	None labeled	...	...	High infestations are occasionally present on double-crop soybeans, but are rarely economic.
Corn earworm	August-September	Orthene (acephate) Sevin (carbaryl) *Lannate, *Nudrin (methomyl)[c] Lorsban (chlorpyrifos) *Penncap-M (microencapsulated methyl parathion)[b] *Pydrin (fenvalerate)[c]	1 1 ½ 1 1 0.1-0.2	On foliage	Damage occurs when larvae feed on pods. Apply control if populations exceed 1 per foot of row.

* Use restricted to certified applicators only.
[a] See Table 15 for insecticide restrictions.
[b] This product is highly toxic to bees.
[c] To be applied only by experienced operators or those wearing protective clothing.

Table 7. Alfalfa and Clover

Insect	Time of attack	Insecticide[a, b]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Clover leaf weevil	March-April	malathion	1	On foliage	When larvae are numerous (5 or more per crown) and leaf feeding is noticeable, usually in early to mid-April.
Alfalfa weevil (spring treatment for larvae)	March-June	*Furadan (carbofuran)[c] *Supracide (methidathion)[e] malathion plus methoxychlor Imidan (phosmet) *Penncap-M (microencapsulated methyl parathion)[d] Lorsban (chlorpyrifos)[e]	¼-½ ½ 2 qt. per acre 1 ½ 1	On foliage	Refer to circular 1136. Or when 25% of tips are being skeletonized and if there are 3 or more larvae per stem, treat immediately. Do not apply sprays during bloom. Instead, cut and remove the hay. Two treatments may be necessary on first cutting. Watch regrowth for signs of damage, and treat if feeding damage is apparent.
		To avoid injury to bees, do not spray alfalfa during bloom.			
Alfalfa weevil adults	June	*Furadan (carbofuran)[c] *methyl parathion *Penncap-M (microencapsulated methyl parathion)[d]	½-1 ½ ½-¾	On foliage	As a stubble spray. Technically, Lorsban and Supracide could be used, since the labels do not distinguish between larvae and adults.
Spittlebug	Late April, May	malathion plus methoxychlor malathion *Penncap-M (microencapsulated methyl parathion)[d]	2 qt. per acre 1 ½-¾	On foliage	When spittle masses are found and nymphs average more than 1 per stem.
Cutworms	May-June	Sevin (carbaryl) Dylox, Proxol (trichlorfon) *Lannate, *Nudrin (methomyl)[c] Lorsban (chlorpyrifos)[e]	1½ 1 ½ ½-1	On foliage	As needed on regrowth of second cutting.
Aphids	April-August	Cygon, De-Fend (dimethoate)[c] diazinon malathion *Furadan (carbofuran)[c] *Penncap-M (microencapsulated methyl parathion)[d] *Supracide (methidathion)[e] *Lannate, *Nudrin (methomyl)[c] Lorsban (chlorpyrifos)[e]	¼-½ ½ 1 ¼-½ ½ ½-1 ½ ½-1	On foliage	When aphids are abundant and lady beetle larvae and adults, parasites, and diseases are not abundant.
Leafhoppers	June-August	Sevin, Savit (carbaryl) diazinon *Penncap-M (microencapsulated methyl parathion)[d] Cygon, De-Fend (dimethoate)[c] Lorsban (chlorpyrifos)[e] *Supracide (methidathion)[c] *Furadan (carbofuran)[c]	1 ½ ½ ¼-½ ½-1 ½-1 ½-1	On foliage	Treatment is justified at these combinations of alfalfa height and leafhopper numbers: Alfalfa height (inches) — Leafhoppers per sweep 0-3 — 0.2 3-6 — 0.5 6-12 — 1.0 12 or taller — 1.5
Grasshoppers	June-September	Cygon, De-Fend (dimethoate)[c] Sevin, Savit (carbaryl) *Furadan (carbofuran)[c] diazinon Lorsban (chlorpyrifos)[e] *Penncap-M (microencapsulated methyl parathion)[d]	½ 1 ¼ ½ ¼-½ ½	On foliage	When grasshoppers are small and before damage is severe. Avoid treatments when plants are blooming. Cut the hay and remove the crop.
Plant bugs	June-August	Cygon, De-Fend (dimethoate)[e] diazinon Furadan (carbofuran)[c] Lorsban (chlorpyrifos)[e]	¼-½ ½ 1 ½-1	On foliage	When tip damage is obvious and nymphs and adults are numerous.

Table 7. Alfalfa and Clover (continued)

Insect	Time of attack	Insecticide[a, b]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Webworms	July-August	Sevin, Savit (carbaryl) Dylox, Proxol (trichlorfon) malathion plus methoxychlor	1 1 2 qt. per acre	On foliage	If damage appears.
Fall armyworm	August-September	Sevin (carbaryl) Dylox (trichlorfon) *Lannate, *Nudrin (methomyl)[c] Lorsban (chloropyrifos)[e]	1 1 ½ ½	On foliage	Usually in late summer or early fall on new seedings or established stands.

* Use restricted to certified applicators only.
[a] See Table 15 for insecticide restrictions.
[b] Before applying insecticides, be certain to clean all herbicides out of equipment. During pollination, apply very late in day or, if possible, avoid application during bloom.
[c] To be applied only by experienced operators or those wearing protective clothing.
[d] This product is highly toxic to bees exposed to direct treatment or residues on crops.
[e] Young, tender, rapidly growing alfalfa may show some phytotoxic symptoms when treated with Lorsban 4E.

Table 8. Grain Sorghum

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Cutworms	May-June	Sevin (carbaryl)	2	Over row	When seedling plants are being cut.
Yellow sugarcane aphid	May-June	Cygon (dimethoate)[b]	¼-½	Over row	Treatment should be applied at first sign of damage to seedling sorghum; 5 to 10 aphids per leaf.
Greenbug	June-July	Cygon, De-Fend (dimethoate)[b] malathion diazinon	¼ 1 ½	Over row	When greenbug damage is sufficient to cause death of more than 2 normal-sized leaves before the hard-dough stage. CAUTION: some sorghum varieties are sensitive to organophosphate insecticides.
Grasshoppers	June-August	Cygon (dimethoate)[b]	½	Over row	As needed.
Fall armyworm	July-August	Sevin (carbaryl) *Lannate, *Nudrin (methomyl)[b]	1½ ¼-½	Over row	When there is an average of 2 worms per head. Leaf feeding or whorl damage is seldom economic.
Webworms	After heads form	Sevin, Savit (carbaryl) *Lannate, *Nudrin (methomyl)[b]	1-2 ½	Over row	When 5 or more larvae per head are found.
Corn earworm	After heads form	Sevin, Savit (carbaryl) *Lannate, *Nudrin (methomyl)[b]	1-2 ¼-½	Over row	When there is an average of 2 worms per head.
Sorghum midge	August-September	Cygon (dimethoate)[b] diazinon Sevin (carbaryl) *Lannate, *Nudrin (methomyl)[b] Lorsban (chlorpyrifos)[c]	¼ ¼-½ 1½ ¼-½ ¼	Over row	Apply during bloom when 50% of heads have begun to bloom and there are 1 or more midge adults (flies) per head.
Corn leaf aphid	July-September	Cygon (dimethoate)[b] malathion	¼ 1	Over row	Corn leaf aphids rarely cause economic damage unless populations are heavy and drouth conditions exist.
Chinch bug	June-August	Sevin (carbaryl)	2	At plant base	

* Liquid formulations are restricted to certified applicators only.
[a] See Table 15 for insecticide restrictions.
[b] To be applied only by experienced operators or those wearing protective clothing.
[c] To avoid phytotoxicity, do not treat plants that are under extreme heat and drouth stress.

Table 9. Small Grains (Barley, Oats, Rye, Wheat)

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Armyworm	May-June	Dylox, Proxol (trichlorfon) *Lannate, *Nudrin (methomyl)[b] Sevin (carbaryl) *Penncap-M (microencapsulated methyl parathion)[c]	½-1 ½ 1 ½-¾	On foliage	When there are 6 or more armyworms per linear foot of row and before extensive head cutting occurs. Do not use trichlorfon on rye.
Greenbug, English grain aphid, oat bird-cherry aphid	May-June	Cygon (dimethoate)[b] malathion *Penncap-M (microencapsulated methyl parathion)[c]	¼ 1 ¼	On foliage	Aphids damage plants indirectly by transmitting disease. Once yellowing is noticeable, it is usually too late to treat. Use dimethoate on wheat only. Do not apply Penncap-M to rye.
Fall armyworm	October-November	Dylox, Proxol (trichlorfon) Sevin (carbaryl)	½-1 1	On foliage	During fall when damage to new growth is apparent. Do not use trichlorfon on corn.
Variegated cutworm	May-June	Dylox, Proxol (trichlorfon)	½-1		As needed. Do not use trichlorfon on corn.
Wheat stem maggot	May-June	None	..	...	No chemical control. Damage shows as white heads when field is still green.
Grasshoppers	Fall	malathion Cygon (dimethoate)[b] *Penncap-M (microencapsulated methyl parathion)[c] *Furadan (carbofuran)[b] Sevin (carbaryl)	1 ½ ½ ⅛-¼ 1	On foliage	During fall when damage is apparent, treat field borders and noncrop areas to stop migration.

* Use restricted to certified applicators only.
[a] See Table 15 for insecticide restrictions.
[b] To be applied only by an experienced operator or one wearing protective clothing.
[c] This product is highly toxic to bees.

Table 10. Grass Pasture

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Grasshoppers	June-July	*Penncap-M (microencapsulated methyl parathion)[b] diazinon malathion Sevin (carbaryl)	½ ½ 1 1	On foliage	As needed.
Armyworms	June-July	Dylox, Proxol (trichlorfon) malathion Sevin (carbaryl)	1 1 1	On foliage	As needed. Sevin and Dylox may be applied without removal of grazing livestock.

* Use restricted to certified applicators only.
[a] See Table 15 for insecticide restrictions.
[b] This product is highly toxic to bees.

Table 11. Stored Grain (Corn, Wheat, Oats)[a, b]

Insect	Time of attack	Insecticide and dilution	Dosage	Placement	Suggestions
Angoumois grain moth (earcorn)	May-October (southern ⅓ of Illinois only)	malathion 57% E.C. 3 oz. per gal. water	Apply to runoff	Spray surface and sides about May 1 and August 1	Plant tight husk varieties. Store as shelled corn to avoid all but surface damage by angoumois moth.
Indian meal moth[c]	May-October	dichlorvos 20% (DDVP, Vapona) plastic resin strip[d]	1 strip per 1,000 cubic feet of space above grain mass	Attach to ceiling or side wall	Clean and spray bin with 1.5% malathion to runoff before storage. Store only clean, dry grain. Install strips on May 15 or at storage. Replace strips every 6 weeks between May and October. As an alternative to the strips, apply *Bacillus thuringiensis* (B.t.) at the auger as the grain is binned.[f] **Note: Level the grain after treatment.** For emergency treatment use B.t. raked in and the dichlorvos resin strip.
		Bacillus thuringiensis[e] dust 4,000 units per mg.	½ oz. per bu. (See Table 12.)	Apply to top 4 inches of grain	
		Bacillus thuringiensis[e] WP 16,000 units per mg. 1 lb. in 10 gal. water	0.6 pt. per bu. (See Table 12.)	Apply to top 4 inches of grain	
		Bacillus thuringiensis[e] LC 4,000 units per mg. 4 pt. in 10 gal. water	0.6 pt. per bu. (See Table 12.)	Apply to top 4 inches of grain	
GENERAL Internal and external feeders Rice and granary weevils Flat grain beetle Saw-toothed grain beetle Rusty grain beetle Foreign grain beetle Cadelle beetle Flour beetles	May-October	malathion 57% E.C. 1 pt. per 3-5 gal. water[g]	2-5 gal. per 1,000 bu.	Spray uniformly as grain is binned. After binning apply 2 gallons per 1,000 square feet over the surface.	Clean and spray bin with 1.5% malathion to runoff before storage. Store only clean, dry grain. Protect surface with dichlorvos resin strips or B.t. as recommended for meal moths.
		malathion 6% wheat flour dust[g]	10 lb. per 1,000 bu.	Apply over grain in combine hopper or uniformly as grain is binned. After binning, apply 5 pounds of 6% or 15 pounds of 2% per 1,000 square feet over the surface.	
		malathion 2% wheat flour dust[g]	30 lb. per 1,000 bu.		
		liquid fumigant [h, i]	3-5 gal. per 1,000 bu.	On surface; repeat if necessary	Clean and spray bin with 1.5% malathion to runoff before storage. Store only clean, dry grain. Apply in late July and September in the southern half of Illinois; apply in mid-August in the northern half of Illinois. Protect surface with dichlorvos resin strips or B.t. as recommended for meal moths.
		*methyl bromide + *ethylene dibromide [i, j]	As directed	On surface	
		*aluminum phosphide[k]	180 tablets or 300 pellets per 1,000 bu.	Uniformly throughout	Fumigants are best used for emergency control of existing infestations.

Table 11. Stored Grain (Corn, Wheat, Oats)[a, b] (continued)

*Use restricted to certified applicators only.
[a] Corn need not be treated if harvested after October 1 unless it is to be carried over after May 15 the following year. Wheat and oats should be treated if they are to be held for one month or more in storage after harvest. Soybeans stored at safe moisture levels are attacked only by Indian meal moth.
[b] Grain carried over after May 15 of the following year should receive a surface spray of 1.5% malathion at 2 gal. per 1,000 sq. ft. or a dust treatment of 6 percent malathion dust at 5 pounds per 1,000 sq. ft. for general feeders and either a B.t. or dichlorvos resin strip application for Indian meal moth control.
[c] Remove webbing before treatment.
[d] Effective only in enclosed bins. Kills adult moths but not the eggs or larvae. A week or two is required to control effectively an existing infestation. Fumigate the grain if immediate control is desired. Also cleared for use in bins of stored soybeans.
[e] Kills larvae only. A week or two is required to control an existing infestation. Fumigate the grain if immediate control is desired. Cleared for use on soybeans. Called Dipel, Topside, and SOK-BT.
[f] We do not recommend the raked-in method of application for B.t. on grain just going into storage.
[g] Use only the grade of malathion labeled for use on stored grain. Apply after drying, because malathion vaporizes and is lost rapidly when grain is heat dried.
[h] Two common liquid fumigants are *carbon bisulfide + *carbon tetrachloride and *ethylene dichloride + *carbon tetrachloride.
[i] Use with extreme caution. Apply only under calm conditions and when grain temperature is 70°F or above. Grain should be 8 inches below the lip of the bin and should be leveled before fumigating. Cover the surface with a plastic tarp for 24 hours, then air out.
[j] Called the 73 mixture.
[k] Called *Phostoxin or *Detia. Slow vaporization with a 3-day exposure period. Can be used at grain temperature of 60°F or above. Grain should be 8 inches below the lip of the bin and should be leveled before fumigating. Cover the surface with a plastic tarp for 3 days, then air out.

Table 12. Amount of *Bacillus thuringiensis* (B.t.) to Apply

Bin diameter (feet)	Bushels in top 4 inches of grain	Amount of B.t. wettable powder (lb.) and water (gal.) needed	Amount of B.t. liquid concentrate (oz.) and water (gal.) needed	Amount of B.t. dust (oz.) needed
8	13	0.1/1	6½/1	6½
12	30	0.25/2½	14½/2½	15
16	53	0.4/4	26/4	27
20	84	0.6/6	39/6	42
24	120	0.9/9	58/9	60
28	163	1.25/12½	80/12½	82
32	214	1.6/16	103/16	107

Table 13. Noncrop Areas

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Grasshoppers	June-July	Sevin (carbaryl) Cygon (dimethoate)[b], † diazinon malathion *Pydrin (fenvalerate)[b]	1 ½ ½ 1 0.05-1	On foliage	When grasshopper nymphs average 15 to 20 per square yard along roadsides and fencerows. Do not spray areas adjacent to water or where runoff is likely to occur. Apply treatments while hoppers are small and before they migrate into row crops.

[a] See Table 15 for insecticide restrictions.
[b] To be applied only by an experienced operator or one wearing protective clothing.
† State labeled insecticide. Applicator must have Illinois label in possession at time of application.

Table 14. Sunflowers

Insect	Time of attack	Insecticide[a]	Pounds of active ingredient per acre	Placement	Timing of application, comments
Cutworms	May-June	Sevin (carbaryl) Lorsban (chlorpyrifos)	1½ 1-1½	Over row	When 10% of the seedlings are damaged.
Sunflower beetle	May-June	Sevin (carbaryl)	1-2	Over row	When defoliation reaches 25%.
Grasshoppers	June-August	Sevin (carbaryl) Lorsban (chlorpyrifos)	1 ½	Over row	When defoliation reaches 25%.
Sunflower moth larvae	July	*Supracide (methidathion)[b] Lorsban (chlorpyrifos)	½ ½	Over row	Apply first treatment when a field has reached 20 to 25% bloom and moths are present.
Stem weevil	June	Sevin (carbaryl) *Supracide (methidathion)[b] Lorsban (chlorpyrifos)	1-2 ½ ½	Over row	When there are 2 or more beetles per plant.
Armyworm	May-August	Sevin (carbaryl)	1½-2	Over row	When defoliation reaches 25%.
Fall armyworm	July-August	Sevin (carbaryl)	1½-2	Over row	When defoliation reaches 25%.

* Use restricted to certified applicators only.
[a] See Table 15 for insecticide restrictions.
[b] To be applied only by experienced operators or those wearing protective clothing.

**Spraying blossoming sunflowers can be extremely hazardous to bees.
Coordinate with local beekeepers before applying sprays.**

Table 15. Limitations in Days Between Application of the Insecticide and Harvest of Crop and Restrictions on Use of Insecticides for Field Crop Insect Control (These are only guidelines — read the label for more detailed information)

(Blanks denote that the product may not be labeled or suggested for that specific use in Illinois)

	Worker re-entry time (hours)[a]	Field corn		Sorghum	Forage crops		
		Grain	Ensilage		Alfalfa	Clover	Pasture
*Amaze (isofenfos)[b]	...	75,A	75,A	...	...	...	...
Counter (terbufos)	...	B	30,C	...	...	...	...
Cygon, De-Fend (dimethoate)[b]	...	14	14	28	10,D	...	...
Diazinon	...	B	10	7	7	7	0
**Di-Syston (disulfoton)[a,b]	...	40	40	...	...	...	...
**Dyfonate (fonofos)[b]	...	30	30	...	...	...	...
Dylox, Proxol (trichlorfon)	...	E	E	...	0	0	0
Ethion	24	50,F	50,F	...	...	...	...
**Furadan (carbofuran)[b]	...	G,H	G,H	...	G,I	...	...
Imidan (phosmet)	...	14	14	...	7,D	...	...
**Lannate (methomyl)[a,b]	...	B	3	14	7	...	...
Lorsban (chlorpyrifos)	...	35,J	14,J	14,K	14-21,L	...	...
Malathion	...	5	5	7	0	0	0
Methoxychlor	...	...	...	...	7	7	...
**Mocap (ethoprop)[b]	...	B	B	...	...	...	...
**Nudrin (methomyl)[a,b]	...	B	3	14	7	...	...
*Penncap-M (microencapsulated methyl parathion)[a,b]	...	12	12	...	15	...	15
*Pydrin (fenvalerate)[a,b]	...	60,M	60,M	...	...	...	...
Sevin, Savit (carbaryl)	...	B	B	21	0	0	0
*Supracide (methidathion)[b]	...	...	...	...	10,N	...	...
Thimet (phorate)	...	30,P	30,P	...	...	...	...

Table 15. Limitations (continued)

	Barley	Oats	Rye	Wheat	Soybeans	Sun-flowers
Cygon (dimethoate)[b]	...	...	...	60	21	...
Dipel, Thuricide, Bactur, SOK (*Bacillus thuringiensis*)	...	...	...	...	0	...
Dylox (trichlorfon)	21	21	...	21	...	...
**Furadan (carbofuran)	G,Q	G,Q	...	G,Q	...	...
**Lannate (methomyl)[a, b]	10	10	10	10	14	...
Lorsban (chlorpyrifos)	...	...	...	...	28,R	42,S
Malathion	7	7	7	7	3	...
**Nudrin (methomyl)[a, b]	10	10	10	10	14	...
Orthene (acephate)	...	...	...	...	14,T	...
*Penncap-M (microencapsulated methyl parathion)[a, b]	15	15	...	15	20,U	...
*Pydrin (fenvalerate)	...	...	...	...	21,V	...
Sevin (carbaryl)	...	...	...	21,W	0	60,T
*Supracide (methidathion)[b]	...	...	...	...	...	50,T

A. Do not use for forage, fodder, or ensilage or harvest fresh corn (including sweet corn) or corn grain within 75 days of last application. Make only one application per season either at planting or cultivation. Soybeans may be planted one year after application. Other crops not listed on the label may be planted 10 months after application.

B. No specific restriction when used as recommended.

C. Do not graze or cut for forage within 30 days of treatment. Only 1 postemergence incorporated treatment or 1 cultivation-time treatment may be used in addition to treatment at planting time.

D. Apply only once per cutting; do not apply during bloom.

E. Three applications may be made per season. Can be applied up to harvest.

F. Do not make more than 1 application after ear formation. Do not feed treated forage to livestock.

G. Do not rotate to a succeeding crop other than alfalfa, corn (field, pop, or sweet), cotton, cucurbits, (cucumbers, melons, pumpkins, or squash), grapes, peanuts, peppers, potatoes, rice, small grains (barley, oats, or wheat), sorghum, soybeans, strawberries, sugar beets, sugarcane, and tobacco. Tomatoes, cabbage, peas, succulent beans, and dry beans may be planted the following season provided the prior season's application did not exceed 8.7 pounds per acre of Furadan 15G, 13 pounds per acre of Furadan 10G, or 2 pints 10 fluid ounces of Furadan 4F. Any other crop may be planted if it is not harvested or grazed.

H. Do not make a foliar application if Furadan 15G was applied at more than 8 ounces per 1,000 linear feet of row (6.7 pounds per acre with 40-inch row spacing) at planting. Do not make more than 2 foliar applications per season.

I. Make no more than 2 applications per season. Do not apply more than once per cutting. Do not use more than 1 pint per acre in the second application. Apply only to fields planted to pure stands of alfalfa. When using no more than ¼ pound per acre, allow 7 days between application and harvest. When using ¼ to ½ pound per acre, allow 14 days between application and harvest. When using ½ to 1 pound per acre, allow 28 days between application and harvest.

J. Do not make more than 1 preplant broadcast or planting-time application of Lorsban 15G per season. Do not make more than 2 postplant applications of Lorsban 15G per season. Do not apply more than 15 pints of Lorsban 4E per acre per season. Do not allow livestock to graze in treated areas nor feed treated corn silage to meat or dairy animals within 14 days after treatment.

K. Do not exceed 3 applications. The treated crop is not to be used for forage, fodder, hay, or silage within 14 days after last treatment. Do not treat sweet varieties of sorghum.

L. Do not apply more than once per cutting. Do not cut or graze treated alfalfa within 14 days after application of 1 pint of Lorsban 4E per acre, nor within 21 days after application of rates above 1 pint per acre. Do not make more than 4 applications per year.

M. Do not exceed 0.4 pound of active ingredient per acre per season. Crops on the label may be planted immediately after last treatment. Do not plant other root crops within 12 months or all other crops within 60 days after last treatment.

N. Make no more than 1 foliage and 1 stubble application per cutting.

P. Do not make any later applications after cultivation treatment. Do not graze or cut for forage within 30 days of treatment. Do not apply under prolonged drought conditions.

Q. Apply before heads emerge from boot. Do not make more than 2 applications per season. Do not feed treated forage to livestock.

R. Do not apply more than 6 pints of Lorsban 4E per acre or 3 pounds of chlorpyrifos (active ingredient) per acre per season. Do not apply last treatment within 28 days before harvest nor apply last 2 treatments closer than 14 days apart. Do not allow livestock to graze in treated areas nor otherwise feed treated soybean forage to meat or dairy animals within 14 days after application. Do not feed straw from treated soybeans to meat or dairy animals within 28 days after application.

S. Do not apply more than 9 pints of Lorsban 4E per acre per season. Do not apply within 42 days before harvest. Do not allow livestock to graze in treated areas.

T. Do not graze or feed treated crop to livestock.

U. Do not make more than 2 applications per season.

V. Do not feed or graze livestock on treated plants. Do not make more than 4 spray applications per season.

W. Do not make more than 2 applications after grain heads emerge from boot. There is no time limitation on green wheat used as pasture or forage.

* Use restricted to certified applicators only.

** Liquid formulations are restricted.

[a] Workers should be warned in advance of treatments. Workers may not enter fields treated with the insecticides without wearing protective clothing for the intervals indicated. They may not enter a field treated with other insecticides without protective clothing until the spray has dried or the dust has settled. Protective clothing includes a hat, long-sleeved shirt, long-legged pants, and shoes and socks.

[b] Sprays to be applied only by experienced operators wearing proper protective clothing.

Table 16. Relative Toxicities of Commonly Used Agricultural Insecticides

Trade name	Chemical name	Toxicity to mammals[a] Acute oral	Toxicity to mammals[a] Acute dermal	Toxicity to Birds	Toxicity to Fish	Toxicity to Bees
**Amaze	isofenphos	high	high	high	high	...
Counter	terbufos	high	high	high	very high	...
Cygon, De-Fend	dimethoate	moderate	moderate	moderate	very low	high
Diazinon	diazinon	moderate	moderate	high	high	high
Dipel, Bactur, Topside, Thuricide, SOK	*Bacillus thuringiensis*	very low	very low	very low	very low	very low
**Di-Syston	disulfoton	high	high	moderate	...	moderate
**Dyfonate	fonofos	high	moderate	moderate	...	...
Dylox, Proxol	trichlorfon	low	low	low	very low	low
Ethion	ethion	high	high	low	...	very low
**Furadan	carbofuran	high	moderate	moderate	moderate	high
Imidan	phosmet	moderate	low	low	...	high
**Lannate, **Nudrin	methomyl	high	moderate	low	...	high
Lorsban	chlorpyrifos	moderate	moderate	moderate	very high	high
Malathion	malathion	low	low	low	moderate	high
Methoxychlor	methoxychlor	low	low	very low	very high	low
*Methyl parathion	methyl parathion	high	high	moderate	very low	high
**Mocap	ethoprop	moderate	high	moderate	...	moderate
Orthene	acephate	moderate	moderate	moderate	low	high
*Penncap-M	microencapsulated methyl parathion	moderate	low	moderate	very low	high
*Pydrin	fenvalerate	moderate	low	low	very high	very high
Sevin	carbaryl	low	low	very low	very low	high
*Supracide	methidathion	high	moderate	moderate	high	high
Thimet	phorate	high	high	moderate	very high	moderate

* Use restricted to certified applicators only.
** Liquid formulations are restricted. Amaze 20G is also restricted.
[a] Relative toxicities based on acute oral and acute dermal LD_{50} values of technical insecticide. Toxicities of formulated materials vary.

Always read the label before applying insecticides.

The suggestions given in this circular are revised annually by entomologists of the College of Agriculture and the Illinois Natural History Survey.

1983 Insect Pest Management Guide

HOME, YARD, and GARDEN

MUCH HAS BEEN SAID ABOUT THE EFFECTS of pesticides, particularly insecticides, on the health and well-being of the American people. However, as you are also aware, you are constantly faced with a horde of insects, intent upon destroying your property or making your life uncomfortable. Destruction of crop residues, varietal selection, hand-picking, fertilization, tree pruning, irrigation, screening, and other practices may reduce the number of insects with which you must contend. Occasionally, you can avoid or at least reduce the destruction caused by some pests without using an insecticide. For most insects, though, you must rely on an insecticide to provide the satisfactory management you want.

By using insecticides and other pest-management tools carefully, you can enjoy reasonable freedom from insects without endangering yourself, your family, or your pets. You must recognize, however, that insecticides are designed to destroy one group of animals — insects — and can be harmful to other animals, including man himself, if used without regard for normal safety precautions. It is up to each insecticide user to handle, apply, and store insecticides safely in order to reap their benefits without suffering from their dangers.

This publication lists certain insecticides with which to control insect pests of food, fabrics, structures, man and animals, lawns, shrubs, trees, flowers, and vegetables. We have tried to suggest only the safest materials. Many people prefer to employ the services of a professional exterminator or custom applicator rather than to become involved in the selection and application of insecticides.

The names used in the tables are the common, coined chemical names, not the trade names, and as such may not be familiar to you. For instance, the common name for *Cygon* is *dimethoate*. If there is no coined chemical name, the trade name is used but is capitalized.

Requested label clearances for a few uses of some insecticides, carriers, and solvents are uncertain for 1983, since many requests have not yet been officially cleared. Consequently, labels may be cancelled and the product removed from the market at any time. Anticipating this, we took a conservative attitude a few years ago and began modifying these suggested uses. We have attempted to anticipate any further label changes in 1983, but there still may be an occasional use cancelled. Check with your local county Extension adviser if you are not sure about the insecticide you plan to use. We will make announcements about label changes through the news media and newsletters in an attempt to keep you up to date.

Insecticides are being classified for *general use* or *restricted use* by the U.S. Environmental Protection Agency. Only a few insecticides have been classified for restricted use at this time. No insecticides listed in this circular have a restricted-use classification. A person wishing to use an insecticide classified for restricted use must be certified as a private or commercial pesticide applicator by the State of Illinois. Contact your county Extension adviser in agriculture for details about that program.

Suggestions for the use of insecticides, effective from a practical standpoint, are based on available data. Many factors affect efficiency of control. Please report details of control failures to us.

In using these tables, always read the footnotes before using the insecticides. The footnotes list precautions and other pertinent information.

The suggestions given in this circular are subject to change without notification during the year.

Leaflets describing the life history, habits, and damage of specific insects and nonchemical methods of control can be obtained from your county Extension adviser or by writing to Entomology Extension, 172 Natural Resources Building, 607 E. Peabody Drive, Champaign, Illinois 61820. These leaflets are indicated by an NHE number in the tables.

This circular was prepared by entomologists of the University of Illinois College of Agriculture and the Illinois Natural History Survey.

VEGETABLE INSECTS

Insects	Crop	Insecticide	Suggestions
Aphids (NHE-47) Mites (NHE-58) Thrips	Most garden crops	malathion or diazinon	Apply on foliage to control the insects. Aphids and leafhoppers transmit plant diseases; early control is important. Mites web on the underside of leaves; apply insecticide to underside of leaves early before extensive webbing occurs.
Blister beetles (NHE-72) Cutworms (NHE-77) Flea beetles (NHE-36) Grasshoppers (NHE-74) Leafhoppers (NHE-22) Picnic beetles (NHE-40)	Most garden crops	carbaryl	For cutworms, attach collars of paper, aluminum foil, or metal at planting for small numbers of plants, or apply insecticide to base of plants at first sign of cutting. Control grasshoppers in garden borders when hoppers are small. For picnic beetles, pick and destroy overripe or damaged vegetables.
All cabbage worms (NHE-45)	Cabbage and related crops, salad crops, and leafy vegetables	*Bacillus thuringiensis*[1]	Presence of white butterflies signals start of infestation. Control worms when small. It is almost impossible to raise cole crops in Illinois without controlling these pests.
Hornworms (NHE-130) Fruitworms	Tomatoes	carbaryl *Bacillus thuringiensis*[1]	Handpicking usually provides satisfactory control.
Earworms (NHE-33)	Tomatoes and sweet corn	carbaryl	Apply to late-maturing tomatoes 3 to 4 times at 5- to 10-day intervals from small-fruit stage. Apply at fresh-silk stage to early and late corn every 2 days 4 to 5 times.
Colorado potato beetles	Eggplant, potatoes, tomatoes	carbaryl	Apply as needed. Insects usually present only in late May and June.
Potato leafhoppers (NHE-22)	Potatoes, beans	carbaryl or malathion	Apply 3 to 4 times at weekly intervals starting in late May or early June. Late potatoes and beans require additional treatments. Most serious pest of potatoes and beans in Illinois.
Bean leaf beetles (NHE-67)	Beans	carbaryl	Leaves are riddled in early plantings. Apply once or twice as needed.
Mexican bean beetles	Beans	carbaryl	Except for southern Illinois, only a pest of late beans. Apply insecticide to underside of leaves.
Cucumber beetles (NHE-46)	Vine crops	carbaryl	Apply as soon as beetles appear in spring. When blossoming begins, apply insecticide late in the day so as not to interfere with pollination by bees.
Squash vine borers (NHE-8)	Squash	carbaryl	Make weekly applications to crowns and runners when plants begin to vine. Apply late in day.
Corn borers	Sweet corn	carbaryl	Apply 4 times every 3 days to whorl and ear zone of early corn when feeding appears on whorl leaves.
Soil insects (including grubs, wireworms, root maggots)	All crops	diazinon	Mix 6 fluid ounces of 25% diazinon emulsion in enough water to cover 1,000 sq. ft., usually 2 to 3 gallons. Rake into soil.

Days Between Application and Harvest

	Collards, kale, and other leafy crops	Beans	Lettuce	Cabbage and related crops	Sweet corn	Onions	Vine crops[2]	Tomatoes	Pumpkin	Eggplant	Peas	Potatoes
carbaryl	14	0	14	3	0	..	0	0	0	0	0	0
diazinon	..	7	..	7	2	..	7	3	..	..	0	..
malathion	7	1	14	7	5	3	1	1	3	3	3	0

Amount of Insecticide for Volume of Spray for Vegetable Insects

	1 gal.	6 gal.	100 gal.	Commercial dust
carbaryl (Sevin) 50% W.P.	2 tbl.	¾ cup	2 lb.	5%
diazinon 25% E.C.	2 tsp.	4 tbl.	1 qt.	4%
malathion 50-57% E.C.	2 tsp.	4 tbl.	1 qt.	4%

E.C. = emulsion concentrate; W.P. = wettable powder. An emulsion concentrate is a chemical pesticide dissolved in a solvent to which an emulsifier has been added. It can then be mixed with water to the desired strength before being used.

[1] No time limitations. Sold as Dipel, Thuricide, Bactur, SOK-BT, and others. [2] Apply insecticides late in the day after blossoms have closed to avoid bee kill.

FLOWER INSECTS

Insect	Insecticide[1]	Dosage	Suggestions
Ants, soil-nesting wasps, and sowbugs (NHE-17, 79, 93, 111) White grubs	diazinon 25% E.C.	1 cup per 1,000 sq. ft.	Drench into soil.
Aphids, mealybugs, spittlebugs, lacebugs, scales (NHE-7, 114)	malathion 50-57% E.C. acephate 15.6% E.C.	2 tsp. per gal. water 4 tsp. per gal. water	Spray foliage thoroughly. Repeat treatments may be needed.
Blister beetles (NHE-72)	carbaryl 50% W.P.	2 tbl. per gal. water	Spray foliage. Repeat treatments may be needed.
Cutworms (NHE-77)	diazinon 25% E.C. diazinon 2% granules	6 oz. per 2-3 gal. water 5 lb. per 1,000 sq. ft.	Spray 1,000 sq. ft. soil at base of plants. Do not spray on plant foliage. Small numbers of plants can be protected with collars of paper, aluminum foil, or metal.
Grasshoppers (NHE-74)	carbaryl 50% W.P. malathion 50-57% E.C.	2 tbl. per gal. water 2 tsp. per gal. water	Spray foliage and also adjacent grassy or weedy areas.
Iris borers	dimethoate (Cygon, DeFend) 23.4% E.C. or 25% W.P.	4 tsp. per gal. water	Apply when irises are in bloom, but not on blooms and make only one application. Add a small amount of liquid detergent to spray mix to improve coverage on leaves.
Leaf-feeding beetles	carbaryl 50% W.P. acephate 15.6% E.C.	2 tbl. per gal. water 4 tbl. per gal. water	Spray foliage. Repeat treatments if needed.
Leaf-feeding caterpillars	Same as for leaf-feeding beetles		
Plant bugs and leafhoppers	Same as for leaf-feeding beetles		
Slugs (NHE-84)	metaldehyde bait Mesurol 2% bait		Apply as a bait to soil. Remove old leaves, stalks, poles, boards, and other debris where slugs like to hide and lay eggs.
Spider mites (NHE-58)	dicofol 18.5% E.C.	2 tsp. per gal. water	Pay particular attention to underside of leaves when spraying. Apply 2 or 3 times at weekly intervals.
Springtails (NHE-70)	malathion 50-57% E.C. malathion 4% dust	2 tsp. per gal. water	Spray foliage and soil. Apply to soil at base of plants.
Stalk borers (NHE-24)	Same as for leaf-feeding beetles		Spray foliage thoroughly and frequently.
Thrips	Same as for leaf-feeding beetles		Spray foliage carefully.
White flies (NHE-136)	pyrethrin 0.1% resmethrin	aerosol spray	Spray foliage thoroughly. Repeat in 5 days.

E.C. = emulsion concentrate; W.P. = wettable powder.

[1] Use only one insecticide from those listed. Do not use oil-base sprays on plants. Do not use malathion on African violets. Do not use carbaryl on Boston ivy. Do not use diazinon on ferns. Repeated use of carbaryl foliage sprays may cause mite or aphid infestations to increase and to become damaging. Do not use insecticides during full bloom. Do not use dimethoate on chrysanthemums.

FOR YOUR PROTECTION

1. Store insecticides out of reach of children, irresponsible persons, or animals; store preferably in a locked cabinet.
2. If you use a bait around or in the home, place it after the children have retired and pick it up in the morning before they get up. Furthermore, place it out of their reach. At present we do not encourage the use of baits for insect control.
3. Avoid breathing insecticide sprays and dusts over an extended period. This is particularly true in enclosed areas such as crawl spaces, closets, basements, and attics.
4. Wash with soap and water exposed parts of body and clothes contaminated with insecticide.
5. Wear rubber gloves when handling insecticide concentrates.
6. Do not smoke while handling or using insecticides.
7. Leave unused insecticides in their original containers with the labels on them and in locked cabinets.
8. Triple-rinse empty pesticide containers. Wrap each container in several layers of paper. Dispose of the containers one at a time through the municipal solid-waste-disposal system.
9. Do not leave puddles of spray on impervious surfaces.
10. Do not apply insecticides to fish ponds.
11. Do not apply insecticides near dug wells or cisterns.
12. Observe all precautions listed by the manufacturer on the label.

TREE AND SHRUB INSECTS

Insects	Insecticide[1]	Suggestions[2]
Aphids (NHE-7)	acephate diazinon malathion	Spray foliage thoroughly with force. Repeat as needed.
Bagworms (NHE-6)	acephate carbaryl malathion *Bacillus thuringiensis*[3]	Spray foliage thoroughly. Apply June 15. Later sprays are less effective. For late spraying, use *Bacillus thuringiensis.*
Borers Bronze birch (NHE-143)	dimethoate	Spray trunk and limbs thoroughly in late May and early June. Repeat in 3 weeks. See leaf miner recommendations on insecticide label.
Ash (NHE-145) Lilac (NHE-145) Peach tree	chlorpyrifos	Spray trunk and limbs in mid-June and repeat 4 weeks later.
Cankerworms (NHE-95)	acephate carbaryl malathion *Bacillus thuringiensis*[3]	Spray foliage when feeding or worms are first noticed in spring.
Eastern tent caterpillars	Same as for cankerworms	Spray when nests are first noticed.
Elm leaf beetles (NHE-82)	acephate carbaryl	Spray as soon as damage is noticed.
European pine shoot moths and Nantucket pine moths (NHE-83)	dimethoate	Spray ends of branches thoroughly in late June for European species and in mid-May for Nantucket species.
Fall webworms	acephate carbaryl diazinon malathion *Bacillus thuringiensis*[3]	Spray when first webs appear; clip off and destroy infested branches or burn out webs.
Galls (NHE-80, 81) Elm cockscomb Hickory Maple bladder	diazinon malathion	Spray foliage thoroughly when buds are unfolding. Sprays after galls form on leaves are ineffective.
Hackberry blister	acephate diazinon malathion	Spray foliage thoroughly in late May. Kills psyllids in galls. Sprays after galls form on leaves are ineffective.
Cooley spruce Eastern spruce	diazinon malathion	Apply in late September or October or early spring just before buds swell.
Green-striped mapleworms	Same as for cankerworms	Spray as soon as damage is noticed.
Leaf miners Boxwood Hawthorn Oak	diazinon malathion acephate	Spray foliage thoroughly when miners first appear. Repeat treatment in 10 to 12 days. Use acephate only on oak.
Birch Holly	dimethoate	Repeat treatment in 3 weeks.
Mealybugs	acephate malathion	Spray foliage thoroughly and with force. Repeat in two weeks.
Mimosa webworms (NHE-109)	acephate carbaryl malathion *Bacillus thuringiensis*[3]	Spray foliage thoroughly when first nests appear (June, July). A repeat treatment may be needed.
Mites (NHE-58)	dicofol	Pay particular attention to underside of leaves. Apply 2 or 3 times at weekly intervals.
Oak kermes	malathion	Spray foliage thoroughly about July 1 to kill the crawlers.
Periodical cicadas (NHE-113)	carbaryl	Spray all branches thoroughly when adults appear. Repeat in 7 to 10 days.
Sawflies	carbaryl	Spray as soon as worms or damage is evident.
Scales (NHE-100, 114, 146)	diazinon malathion acephate	Spray foliage thoroughly in early April for *Fletcher* and *European elm scale;* in late May for *pine needle* and *sweet gum scale;* in early June for *scurfy, oystershell,* and *euonymous scales;* in early July for *cottony maple, Juniper,* and *dogwood scales;* in mid-July for *spruce bud scale;* and again in August for *oystershell scale.*

[1] Use only one insecticide of those listed. [2] Treatment dates listed are for central Illinois. In southern Illinois, apply 2 weeks earlier; in northern Illinois, 2 weeks later. [3] Trade names: Dipel, Thuricide, Bactur, SOK-BT, and others.

TREE AND SHRUB INSECTS (continued)

Insects	Insecticide[1]	Suggestions[2]
Scales (cont.)		
Cottony maple (NHE-144), Putnam, San Jose, Tulip tree	dormant oil diluted according to label	Apply when plants are still dormant in late winter. Do not use on evergreens. For tulip tree scale, a malathion spray in late September or in early spring is also effective.
Sycamore lace bugs	acephate carbaryl malathion	Spray when nymphs appear, usually in late May.
Thrips	Same as for aphids	Mainly on privet. Spray foliage thoroughly.
Yellow-necked caterpillars	acephate carbaryl malathion	Spray foliage when worms are small.
Zimmerman pine moths (NHE-83)	chlorpyriphos dimethoate	Spray in mid-April or mid-August.

[1] Use only one insecticide from those listed. [2] Treatment dates listed are for central Illinois. In southern Illinois, apply 2 weeks earlier; in northern Illinois, 2 weeks later.

Amount of Insecticide Needed for Volume of Spray for Tree and Shrub Insects

	1 gal.	6 gal.	100 gal.		1 gal.	6 gal.	100 gal.
acephate (Orthene) 15.6% E.C.[1]	4 tsp.	1 cup	2 qt.	dicofol (Kelthane) 18.5 % E.C.	2 tsp.	4 tbl.	1 qt.
carbaryl (Sevin) 50% W.P.[2]	2 tbl.	¾ cup	2 lb.	dimethoate (Cygon 2E, DeFend 2E)[3]	2 tsp.	4 tbl.	1 qt.
chlorpyrifos (Dursban 2E.)	2 tsp.	4 tbl.	1 qt.				
diazinon 25% E.C.[4]	2 tsp.	4 tbl.	1 qt.	malathion 50-57% E.C.[5]	2 tsp.	4 tbl.	1 qt.

E or E.C. = emulsion concentrate; W.P. = wettable powder.

[1] Do not use on flowering crab, sugar maple, redbud, American elm, Lombardy poplar, or cottonwood. [2] Do not use on Boston ivy. [3] Do not use on chrysanthemums. [4] Do not use on ferns or hibiscus. [5] Do not use on canaert red cedar.

LAWN INSECTS

Insects	Insecticide[1]	Dosage per 1,000 sq. ft.[2]	Suggestions
White grubs (NHE-104,147)	diazinon 25% E.C. 5% G.	1 cup 2½ lb.	Apply as spray or granules to small area and then water in thoroughly before treating another small area. Grub damage will usually occur in late August and in September.
Ants (NHE-111) Cicada killer and other soil-nesting wasps (NHE-57, 79)	diazinon 25% E.C. 5% G. chlorpyrifos 5 or 6% E.C.	¾ cup 2 lb. 1 cup	Apply as spray or granules and water in thoroughly. For individual nests pour 1% diazinon in nest and cover with soil.
Sod webworms (NHE-115)	carbaryl 50% W.P. diazinon 25% E.C. 5% G. chlorpyrifos 5 or 6% E.C. Aspon 13% E.C.	½ lb. ¾ cup 2 lb. 8 fl. oz. (1 cup) 1½ cups	As sprays, use at least 2.5 gal. of water per 1,000 sq. ft. Do not water for 72 hours after treatment. As granules, apply from fertilizer spreader. Webworms usually damage lawns in late July and in August.
Millipedes and sowbugs (NHE-93)	carbaryl 50% W.P. diazinon 25% E.C. chlorpyrifos 5 or 6% E.C.	½ lb. ¾ cup 1 cup	Spray around home where millipedes or sowbugs are crawling. If numerous, treat entire lawn.
Armyworms Cutworms	carbaryl 50% W.P. chlorpyrifos 5 or 6% E.C.	2 oz. 1 cup	Apply as sprays or granules. Use 5 to 10 gal. of water per 1,000 sq. ft.
Chinch bugs	chlorpyrifos 5 or 6% E.C. diazinon 25% E.C. 5% G. Aspon 13% E.C.	1 cup ¾ cup 2 lb. 2⅔ cups	Spray infested areas where chinch bugs are present.
Aphids (NHE-148)	acephate 15.6% E.C. malathion 50-57% E.C. pirimicarb 50% W.P.	4½ fl. oz. 1 tbl. ⅓ oz.	Spray grass thoroughly.
Chiggers	diazinon 25% E.C.	1 tbl.	Spray grass thoroughly.
Slugs (NHE-84)	Mesurol 2% bait		Apply where slugs are numerous. Scatter in grass. For use only in flower gardens and shrubbery beds.

E.C. = emulsion concentrate; W.P. = wettable powder; G. = granules.

[1] Use only one insecticide from those listed. [2] To determine lawn size in square feet, multiply length times width of lawn and subtract non-lawn areas including house, driveway, garden, etc. Do not allow people or pets on the lawn until the spray has dried.

HOUSEHOLD INSECTS

Insects	Insecticide[1]	Dosage	Suggestions
Ants (NHE-111) Crickets (NHE-137) Spiders (NHE-17, 116)	diazinon 25% E.C. chlorpyrifos diazinon propoxur	Dilute to 0.5% with water 0.5% R.T.U. 0.5% R.T.U. 0.5% R.T.U.	Use diazinon E.C. to spray completely around outside foundation and the adjacent 1 ft. of soil. Apply an R.T.U. spray to baseboards, cracks, and door thresholds.
Bed bugs	malathion 50-57% E.C. malathion 1% dust	Dilute to 1% with water R.T.U.	Thoroughly spray slats, springs, and bed frame. Apply a light dust to seams, tufts, and folds of mattresses. Use clean bedding.
Boxelder bugs (NHE-9)	diazinon 25% E.C. carbaryl 50% W.P.	Dilute to 0.5% with water Dilute to 0.25% with water	Spray boxelder bugs on tree trunks, foundation walls (diazinon only), under eaves, and other areas where they gather. *Indoors:* Remove with vacuum.
Carpenter ants (NHE-10)	diazinon 25% E.C. diazinon propoxur	Dilute to 0.5% with water 0.5% R.T.U. 0.5% R.T.U.	Spray nest entrances and runways. Use outside foundation spray as recommended for ants. Treat nests directly for best results. Do not use diazinon E.C. inside.
Carpet beetles, clothes moths (NHE-87)	chlorpyrifos diazinon	0.5% R.T.U. 0.5% R.T.U.	Spray storage areas, edges of carpeting, baseboards, etc. Prevent lint and dust from accumulating. Dry cleaning kills these pests. Store cleaned or washed woolens in insect-free chests and plastic bags.
Centipedes, millipedes, sowbugs (NHE-93)	diazinon 25% E.C. chlorpyrifos diazinon propoxur	Dilute to 0.5% with water 0.5% R.T.U. 0.5% R.T.U. 0.5% R.T.U.	Apply diazinon E.C. as an outside foundation spray. If millipedes are abundant, treat entire lawn according to label. Remove debris from around foundation. *Indoors:* Collect insects with vacuum or use R.T.U. spray according to label.
Chiggers (NHE-127)	diazinon 25% E.C.	Dilute to 0.5% with water	Treat lawns, roadsides, and areas not mowed. For personal protection, a repellent such as DEET will prevent attack. Take a warm, soapy shower or bath immediately after returning from an infested area.
Clover mites (NHE-2)	dicofol 18.5% E.C. pyrethrin	Dilute to 0.03% with water 0.1% R.T.U.	Spray outside of house from ground up to windows and adjacent 10 ft. of lawn. Repeat spray in 7-10 days if necessary. Eliminate grass and weeds from 18-inch strip next to foundation. *Indoors:* Remove with vacuum, or spray with pyrethrin.
Cluster flies (NHE-1)	dichlorvos 20% resin strip[2] pyrethrin	1 strip per 1,000 cu. ft. 0.1% R.T.U.	Place resin strips in attic or other rooms. Fog lightly in rooms with pyrethrin. Repeat spray as needed. Seal cracks around windows, eaves, and siding to prevent entry.
Cockroaches: German (NHE-3) Brown-banded (NHE-4) American, Oriental (NHE-5)	chlorpyrifos diazinon propoxur	0.5% R.T.U. 0.5% R.T.U. 0.5% R.T.U.	Spray roach runways and hiding places. Treat under sink, refrigerator, cabinets, on baseboards, etc. Treatment throughout home may be needed to control brown-banded roaches. May be supplemented with boric acid applied into out-of-sight and out-of-reach voids under cabinets and appliances.
Drain flies (NHE-91)	dichlorvos 20% resin strip[2] pyrethrin	1 strip per 1,000 cu. ft. 0.1% R.T.U.	Use chemicals only after solving sanitation problems. Clean out overflow drains, drain traps, and cellar drains. Pour boiling water or rubbing alcohol into overflow drain to eliminate maggots.
Earwigs (NHE-142)	diazinon 25% E.C. propoxur	Dilute to 0.5% with water 0.5% R.T.U.	Spray completely with diazinon E.C. around the outside foundation wall and the adjacent strip of soil. *Indoors:* Apply R.T.U. spray to baseboards, cracks, and door thresholds.
Elm leaf beetles (NHE-82)	carbaryl 50% W.P. pyrethrin	Dilute to 0.25% with water 0.1% R.T.U.	*Outdoors:* Spray with carbaryl on nearby Chinese elm trees to control elm leaf beetle larvae and adults. Seal cracks around windows to prevent entry. *Indoors:* Remove with vacuum, or spray with pyrethrin.
Fleas (NHE-107)	dichlorvos or naled	flea collars	Replace flea collars on pets about every 3 months. Some pets are allergic.
	carbaryl malathion	5% dust 4% dust	Dust pets directly as needed. Dust areas inside and outside the home where pets rest. Vacuum pets and inside areas after 30 minutes.

E.C. = emulsion concentrate; W.P. = wettable powder; R.T.U. = ready to use; G. = granules. **SEE THE PESTICIDE DILUTION TABLE.**

[1] Use only one insecticide from those listed. [2] To determine lawn size in square feet, multiply length times width of lawn and subtract non-lawn areas including house, driveway, garden, etc. Do not allow people or pets on the lawn until the spray has dried.

HOUSEHOLD INSECTS (continued)

Insects	Insecticide[1]	Dosage	Suggestions
Fleas (NHE-107) (cont.)	pyrethrin	0.1% R.T.U.	For infestations in the home spray baseboards, rugs, and floors where fleas are observed according to label directions. Vacuum rugs and upholstered furniture thoroughly.
	carbaryl 50% W.P.	4 tbl. per 100 sq. ft.	Apply spray to lawn.
Houseflies (NHE-16) Gnats Midges Mosquitoes (NHE-94, 132) Punkies	*Outdoors:* malathion 50-57% E.C.	Dilute to 1% with water	Spray tall grass and around doorways, refuse containers, and other resting sites. Dispose of refuse twice each week. Eliminate standing water in eave troughs, tires, toys, tin cans, children's swimming pools, etc. Use a repellent like DEET when entering mosquito-infested areas.
	Indoors: pyrethrin dichlorvos 20% resin strips[2]	 0.1% R.T.U. 1 strip per 1,000 cu. ft.	Apply fine mist or fog of pyrethrin. Use screening and keep repaired. Dichlorvos resin strips give good control in tight, enclosed areas for about 3 months. Fly swatters are also effective.
Lice, human (NHE-105)	malathion 1% dust carbaryl 5% dust	1 oz. per adult person	Dust lightly over body hair, and wash clothing and bedding. Repeat in 2 weeks if needed. Do not get in eyes.
Mites, human Human scabies (NHE-135)	Kwell 1% lotion available only by a doctor's prescription		See your physician.
Pantry and cereal insects (NHE-11) Saw-toothed grain beetles, cigarette beetles, etc.	diazinon propoxur pyrethrin	0.5% R.T.U. 0.5% R.T.U. 0.1% R.T.U.	Discard infested packages. Scrub or vacuum food cabinets and shelves. Force spray into cracks and crevices; allow to dry; cover shelves with clean, fresh paper. Do not contaminate food or utensils with insecticide.
Powder-post beetles (NHE-85)	chlorpyrifos 42%	Dilute to 1% with water	Paint or spray infested unfinished wood. Follow label directions. Painting or varnishing wood to seal pores will prevent egg laying and reinfestation.
Silverfish (NHE-86)	diazinon propoxur	0.5% R.T.U. 0.5% R.T.U.	Spray runways, baseboards, closets, and places where pipes go through the walls. Repeat treatments in 2 weeks if needed. Keep books and papers in dry places.
Springtails (NHE-70)	diazinon 25% E.C.	Dilute to 0.5% with water	*Outdoors:* Spray soil next to the house, especially grassy moist areas. Eliminate low moist spots around the house. *Indoors:* Use vacuum. Allow soil to dry in potted plants or planter boxes.
Swimming pool insects (NHE-103)	*Do not* add insecticides to pool water		Remove insects from the pool with dip nets. Clean the pool regularly.
Termites (NHE-57)	chlordane 45 or 72% E.C.	Dilute to 1% with water or oil	For soil injection along the building foundation and under footings, use 1 gal. per 2 cu. ft. of soil. Remove termite mud tubes connecting wood to the soil. Eliminate wood-to-soil contacts. Ventilate to keep unexcavated areas dry.
Ticks (NHE-56): Brown dog tick, wood tick	stirofos 50% W.P. malathion 50-57% E.C. carbaryl 50% W.P.	Dilute to 0.5% with water Dilute to 2.5% with water 4 tbl. per 100 sq. ft.	Apply spray to lawns, fence rows, roadsides, and areas not regularly mowed.
	carbaryl malathion	5% dust 4% dust	Dust pets directly as needed, according to label instructions. Dust baseboards, cracks, and crevices around pet bedding.
Wasps (NHE-141) Hornets Bees	carbaryl diazinon dichlorvos dichlorvos 20% resin strip[2] pyrethrin	5% dust 5% G. 0.5% R.T.U. 1 strip per 1,000 cu. ft. 0.1% R.T.U.	Hang dichlorvos resin strips in attic to prevent infestations. For nests below ground, apply diazinon according to label and seal the opening with soil. Spray above-ground wasp and hornet nests with pyrethrin or dichlorvos. For bees, treat nests in partitions with carbaryl. Drill holes through the siding to inject insecticide, if necessary. Remove nests and honey and destroy them. Treat nests at dusk or dawn.

E.C. = emulsion concentrate; W.P. = wettable powder; R.T.U. = ready to use; G. = granules.

[1] Whenever possible purchase specially prepared ready-to-use forms of insecticides for indoor use. *Use only one insecticide from those listed.* When preparing a quantity of 1 gallon or more of a spray of a desired percentage, use the dilution table on p. 236. You need to know only the formulation of the insecticide when using the dilution table. [2] Do not use in pet shops or if tropical fish are present. Do not use in kitchens, restaurants, or areas where food is present. Do not use in nurseries or rooms where infants, individuals who are ill, or aged persons are confined. Do not use in hospitals or medical clinics.

SEE THE PESTICIDE DILUTION TABLE.

Pesticide Dilution Table for Household Insects

HOW TO USE: When preparing a spray of a desired percentage you need to know only the formulation of the particular product (examples: Kelthane 18.5% wettable powder; Kelthane 18.5% emulsion concentrate). For instance, if you were preparing a 0.5% diazinon solution for spraying the foundation of the home, you would mix 5 tablespoons of diazinon 25% E.C. into each gallon of water. The formulations of insecticides in the table may be purchased from hardware stores, pest control establishments, lawn and garden centers, and other sources. For some jobs, such as spraying outdoors to control flies or mosquitoes, a gallon or more of properly diluted spray is required. To obtain the percent concentration suggested for controlling a particular insect, add the amount of pesticide suggested in the table to one gallon of water. For control of household insects. *Do not* use this table for vegetable, flower, tree, shrub, or lawn insects.

Pesticide formulation	Amt. of insecticide needed per gal. of spray				
	Desired concentration				
	0.03%	0.25%	0.5%	1.0%	2.5%
carbaryl (Sevin) 50% W.P.	..	2 tbsp.	4 tbsp.	8 tbsp.	..
chlordane 45% E.C.	..	..	8 tsp.	5 tbsp.	..
chlordane 72% E.C.	..	..	4 tsp.	8 tsp.	..
diazinon (Spectracide) 25% E.C.	..	..	5 tbsp.	10 tbsp.	..
dicofol (Kelthane) 18.5% E.C.	1½ tsp.	..	..	..	..
malathion 50-57% E.C.	..	..	7 tsp.	4½ tbsp.	10 tbsp.
stirofos 50% W.P.	..	..	4 tbsp.	..	..

(tbsp. = tablespoon; tsp. = teaspoon)

CONVERSION TABLE FOR SMALL QUANTITIES

1 level tablespoon = 3 level teaspoons	1 pint = 2 cups
1 fluid ounce = 2 tablespoons	1 quart = 2 pints or 32 fluid ounces
1 cup = 8 fluid ounces or 16 tablespoons	1 gallon = 4 quarts or 128 fluid ounces

NAMES OF INSECTICIDES

Below is a list of the common names of insecticides used in the preceding tables, followed by the commercial trade name and the chemical name. Some products may be available under a variety of trade names not listed below. Be sure to read the label. The label on the container always lists these products by the common name or chemical name.

Common name	Trade name	Chemical name
acephate	Orthene	O, S-dimethyl acetylphosphoramidothioate
Bacillus thuringiensis	Dipel, Thuricide, Bactur, SOK-BT	
carbaryl	Sevin	1-naphthyl methylcarbamate
chlorpyrifos	Dursban	O, O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate
DEET	Off, Kik	N, N-diethyl-m-toluamide
diazinon	Spectracide	O, O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidyl) phosphorothioate
dichlorvos	Vapona, DDVP	2,2-dichlorovinyl dimethyl phosphate
dicofol	Kelthane	4,4′-dichloro-a-(tri = chloromethyl) benzhydrol
dimethoate	DeFend, Cygon	O, O-dimethyl S-(N-methyl carbamoyl methyl) phosphorodithioate
ethyl hexanediol	6-12, Rutgers 612	2-ethyl-1, 3-hexanediol
malathion	Cythion	diethyl mercaptosuccinate, S-ester with O, O-dimethyl phosphorothioate
pirimicarb	Pirimor	2-(dimethylamino)-5,6-dimethyl-4-pyrimidinyl dimethyl carbamate
propoxur	Baygon	O-isopropoxyphenyl methyl carbamate
propyl thiopyrophosphate	Aspon	0,0,0,0-tetrapropyl dithiopyrophosphate
pyrethrin		principally from plant species *Chrysanthemum cinariaefolium*
resmethrin	Chryson, SBP-1382	(5-benzyl-3-furyl) methyl 2,2 dimethyl-3-(2-methylprophenyl) cyclopropanecarboxylate
stirofos	Rabon	2-chloro-1-(2,4,5,-trichlorophenyl) vinyl dimethyl phosphate

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Tree and Shrub Insects

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Aphids	acephate	1/2	When aphids are numerous.
	malathion	1	
	diazinon	1	
Ash borer	chlorpyrifos	1	Apply in early June and repeat 4 weeks later.
	endosulfan	1	
	acephate	1/2	
Bagworm	malathion	1	Spray foliage thoroughly about June 15 while worms are still small.
	carbaryl	2	
	chlorpyrifos	1/2	
	Bacillus thuringiensis	follow label directions	
	dimethoate	1/2	
	acephate	1/2	
Birch leaf miner	acephate	1 1/3	Spray foliage thoroughly when miners first appear. Repeat 10 to 12 days later.
	malathion	1	
	diazinon	1	
	dimethoate	1/4	
Black vine weevil	endosulfan	1	Spray foliage thoroughly in mid-May when adults are on needles. Allow spray to run off onto soil under shrubs.
	azinphosmethyl	1	
	acephate	1	
Bronze birch borer	dimethoate	1/2	Spray bark of trunk and limbs in late May and repeat 3 weeks later.
Cankerworms	acephate	1/2	Spray when worms are still small as leaf buds are opening in spring.
	malathion	1	
	diazinon	1	
	carbaryl	2	
	Bacillus thuringiensis	follow label directions	
Cicada	carbaryl	2	Spray foliage when egglaying begins. Repeat every 5 days while adult cicadas are present.

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Cooley spruce gall aphid	malathion diazinon endosulfan	1 1 1	Apply in late September or in early spring just before buds swell.
Cottony maple scale	acephate malathion diazinon	2/3 1 1	Spray in July after crawlers have hatched and repeat 10 days later.
	superior oil	2 gallons	Apply in spring before leaf emergence. Do not use on Japanese or sugar maple.
Dogwood borer	endosulfan	1	Apply in mid-May and repeat 4 weeks later.
Eastern spruce gall aphid	malathion diazinon endosulfan chlorpyrifos	1 1 1 1	Apply in late September or in early spring just before buds swell.
Eastern tent caterpillar	acephate malathion diazinon *Bacillus thuringiensis* chlorpyrifos	1/2 1 1 follow label directions 1	Spray areas of tree where nests first appear in early spring.
Elm bark beetles	methoxychlor	...	Contact Section of Applied Botany and Plant Pathology, Illinois Natural History Survey, Urbana, Illinois 61801, for information on Dutch elm disease control.
Elm cockscomb gall	diazinon malathion	1 1	Usually no control is necessary.
Elm leaf beetle	carbaryl acephate diazinon	2 1/2 1	Apply when damage first appears, usually late May.
Eriophyid mites	dicofol	1/2	Spray only when injury is observed. Usually control is not necessary.
Euonymous scale	acephate dimethoate malathion diazinon	2/3 1 1 1	Spray in early June. Make four applications 10 to 12 days apart.

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
European elm scale	malathion	1	Apply in early spring when first leaves appear.
European pine saw-fly	carbaryl chlorpyrifos diazinon	2 1 1	Spray when worms are present and feeding on the needles.
European pine shoot moth	dimethoate	1	Spray ends of branches thoroughly in late June.
Fall webworm	acephate carbaryl malathion diazinon *Bacillus thuringiensis* chlorpyrifos	1/2 2 1 1 follow label directions 1	Spray nests on webbed areas in trees in late summer. Do not apply acephate to crabapple.
Flat-headed apple tree borer	dimethoate	1/2	Spray in late May and repeat twice at 3-week intervals. Keep trees in vigorous growing condition. Wrap trunks of new set trees with paper or burlap.
Fletcher scale	malathion	1	Apply in early April and repeat in early June.
Forest tent caterpillar	acephate carbaryl malathion diazinon	1/3 2 1 1	Spray when caterpillars are present.
Gouty oak gall	...	...	Prune out infested branches and destroy.
Hackberry psyllids	malathion diazinon	1 1	Apply in late May. This insect rarely damages trees.
Hawthorn leaf miner	acephate malathion diazinon	2/3 1 1	Treat in early May or when first sign of leaf-browning appears.
Hawthorn mealy bug	malathion diazinon dimethoate	1 1 1/2	Apply when insects are numerous.
Holly leaf miner	dimethoate acephate	1/2 1/2	Spray foliage in late May or early June when leaf miners first appear.

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Lacebug	acephate carbaryl malathion	1/2 2 1	Spray when bugs are numerous.
Leaf crumpler	malathion diazinon	1 1	Spray in late May and again in late August.
Leafhoppers	carbaryl	2	Spray when hoppers are numerous on foliage.
Lecanium scale	acephate diazinon malathion	2/3 1 1	Apply to infested trees in mid-June and repeat 2 weeks later.
Lilac borer	endosulfan chlorpyrifos	1 1	Apply in mid-May and repeat 4 weeks later.
Locust borer	carbaryl chlorpyrifos	2 1	Apply in late August and again in mid-September.
Locust mite	dicofol	1/2	Apply in early spring just before leaves appear. Repeat spray 2 weeks later.
Magnolia scale	malathion diazinon	1 1	Treat in late September or early spring when buds are opening.
Maple bladder gall	dicofol	1/2	Chemical control usually is not necessary. If infestation has been severe, spray tree as leaf buds are opening in spring.
Mimosa webworm	acephate malathion diazinon *Bacillus thuringiensis* carbaryl chlorpyrifos	1/2 1 1 follow label directions 2 1	Spray in early July or when webs first appear. Repeat in August for second generation.
Mountain ash borer	chlorpyrifos endosulfan	1 1	Treat in early June and repeat 4 weeks later.
Nantucket pine moth	acephate dimethoate	1/2 1	Spray ends of branches in mid-May.
Oak kermes	malathion diazinon	1 1	Apply when crawlers appear on foliage in early July.
Obscure scale	superior oil	2 gallons	Apply in late October or in early spring just prior to leaf emergence.

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Oystershell scale	malathion dimethoate chlorpyrifos	1 1/2 1	Apply in early June and repeat 10 to 12 days later. Repeat sprays again in early August in central and southern Illinois.
Peach tree borer	endosulfan chlorpyrifos	1 1	Spray thoroughly bark of trunk and limbs in mid-June and repeat 4 weeks later.
Periodical cicada	carbaryl	2	Spray when adults are laying eggs in June.
Pine bark aphid	malathion diazinon acephate	1 1 1/3	Spray when aphids are present, usually in May and later. Add spreader.
Pine needle scale	acephate malathion diazinon chlorpyrifos	1/2 1 1 1	Apply spray in late May if trees are infested.
San Jose scale	superior oil	2 gallons	Apply to bark of trunk and limbs in spring prior to leaf emergence.
Spider mites	dicofol Vendex	1/2 1/2	Spray when mites are numerous. Especially serious on juniper.
Spittle bug			No chemical control is necessary.
Taxus mealy bug	acephate malathion diazinon	1/2 1 1	Spray foliage with force when insects are present. Repeat 2 weeks later.
Thrips	malathion acephate	1 1/2	Spray privet when thrips are numerous.
Tuliptree scale	superior oil malathion	2 gallons 1	Apply oil in late spring before leaves emerge. Apply malathion in mid-August.
Twig pruner			No known chemical control.
White-marked tussock moth	malathion carbaryl diazinon	1 2 1	Treat when worms are present in June.
Yellow-necked caterpillar	malathion diazinon acephate chlorpyrifos	1 1 1/2 1	Spray foliage on which caterpillars are feeding, usually in late July.
Zimmerman pine moth	dimethoate chlorpyrifos	1 1	Spray bark and foliage either in April or mid-August.

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Turfgrass Insects

Insects	Insecticide	Lb. of active ingredient per acre	Timing of application
Ants and soil-nesting wasps	diazinon spray	4	Apply when insects are present.
Aphids (greenbug)	acephate	2	Apply only when aphids are present.
	malathion spray	1	
	diazinon spray	1	
	chlorpyrifos spray	1	
Armyworms and cutworms	carbaryl spray or granules	8	Treat when worms are present.
	trichlorfon spray or granules	5	
	chlorpyrifos spray or granules	1	
Chiggers	diazinon	1	Apply to grass area where chiggers have been a problem.
	malathion	1	
Chinch bugs	chlorpyrifos spray	1	Spray when bugs are numerous.
	trichlorfon spray	5	
	diazinon spray	4	
Grubs, including true white, annual white, Japanese beetle, green June beetle	diazinon spray or granules	5	Treat damaged areas and where grubs are present in soil. Water-in very thoroughly immediately after spray application and soon after granular application.
	trichlorfon spray or granules	8	
	isofenphos granules	2	
	bendiocarb spray	2	
Leafhoppers and grasshoppers	carbaryl spray	4	Treatment usually is not necessary unless hoppers are numerous.
Millipedes	carbaryl spray	8	Apply to turf where millipedes are migrating across area.
	diazinon spray	4	
Slugs	Mesurol bait		Apply by scattering in grass.
Sod webworms	carbaryl spray or granules	8	Apply in late July or August when worms are present. Use 120 gallons of water per acre.
	diazinon spray or granules	4	
	chlorpyrifos spray or granules	1	
	trichlorfon spray or granules	5	

Insecticides: Names and Some Commercial Formulations

Common name	Trade names	Formulations
acephate[a]	Orthene	75% S.
azinphosmethyl	Guthion	50% W.
Bacillus thuringiensis	Bactur, Dipel, Thuricide, SOK-BT	
bendiocarb	Turcam	76% W.
carbaryl[b]	Sevin	80% S. 50% W.
chlorpyrifos	Dursban	2 lb./gal. 4 lb./gal. 1% G.
diazinon[c]	Spectracide, Diazinon	4 lb./gal. 25% E.C. 50% W. 14% G. 5% G.
dicofol	Kelthane	18.5% E.C. 18.5% W.
dimethoate[d]	Cygon, De-Fend	2 lb./gal. 25% W.P.
endosulfan	Thiodan	2 lb./gal. E.C. 50% W.
isofenphos	Oftanol	5% G.
malathion[e]	Cythion	50-57% E.C. 25% W.
superior oil	many brands	...
trichlorfon	Dylox, Proxol	80% W. 4 lb./gal.
	Imidan	50% W.
	Vendex	50% W.

[a]Do not use on sugar or Japanese maple, American elm, flowering crab, redbud, cottonwood, or Lombardy poplar.
[b]Do not use on Boston ivy.
[c]Do not use on ferns or hibiscus.
[d]Do not use on chrysanthemums.
[e]Do not use on canaert red cedar.
Note: E.C. = emulsion concentrate; W. = wettable powder; G. = granules; S. = sprayable powder.

The above-named insecticides (except Guthion) are *not* in the restricted-use category, which would require an applicator to be certified before purchasing or using the insecticide.

Alfalfa Weevil Pest Management Program

The most serious pest threatening alfalfa in Illinois is the alfalfa weevil. Alfalfa weevil larvae have green bodies and black heads and are 3/8 inch long when full grown. They feed on alfalfa plants for three or four weeks in the spring. During this time they shed their skins three times. When full grown, they spin silken cocoons on the plants, within the curl of fallen dead leaves, or in litter on the ground. They change into adults in one or two weeks. After feeding for a short time in the spring, these adults fly to protected areas and enter a resting period. In Illinois, most of the adults will return to the alfalfa fields in late summer and early fall.

In southern Illinois, if temperatures permit, the weevils will lay eggs throughout the fall and winter as well as into the spring. Some of the eggs will begin to hatch about the time alfalfa is beginning its spring growth. In the more northerly counties, the larger number of eggs are laid in the spring. By the time the larvae emerge, the alfalfa is 6 to 10 inches tall and can tolerate more weevils than the southern crop.

Because population peaks vary from year to year, it is difficult to predict when spraying will be necessary. Older methods of determining when to spray (such as percent tip feeding) are often confusing and do not consider crop height or weevil numbers.

CONTROL METHODS AVAILABLE

Although insecticidal control has been the most widely used method, two other methods are common. One is to manipulate the timing of the first harvest in the spring. After considering many factors such as numbers of weevil larvae, plant growth, and prevailing weather conditions, you can time the cutting date and achieve the same effect as if you had applied an insecticide. The other method involves biological control agents, such as parasites and predators. One of the most successful biocontrol agents in Illinois is a small parasitic wasp, *Bathyplectes curculionis*. This wasp lays its eggs inside young weevil larvae. The wasp larvae develop inside the weevil larvae, and when they have satisfied their needs, they kill their hosts.

PURPOSE OF ALFALFA WEEVIL PEST MANAGEMENT

The principal reason we have a pest management program is that the three control methods are interrelated. For example, insecticides kill parasites and predators as well as alfalfa weevils. Harvesting alfalfa when many of the weevil larvae are parasitized will also reduce the parasite population. To help understand how the three methods of control work together, a computer-based mathematical model was developed. This model simulates field conditions. The pest management program presented in this circular resulted from laboratory analysis of the model, followed by extensive field trials. The values in Recommendation Charts 1 and 2 were taken directly from these trials. The charts are designed to make the benefits of the model available to you without requiring that you have access to a computer.

Remember that this program assumes proper soil pH, adequate fertility, and that the alfalfa is not under stress from drouth, disease, or other factors. If these conditions are not met, it is possible that excessive feeding injury will occur.

HOW TO USE THE PROGRAM

To use this program you will have to do the following things:

1. Calculate degree-day accumulation by recording daily high and low temperatures from January 1 until the end of the alfalfa weevil season in late spring. The National Weather Service computes degree-day accumulations for this alfalfa weevil management program and includes them in its agricultural advisory. This advisory is received by most newspaper, radio, and television services in Illinois. If your local paper or station were aware that you were interested in this information, they would probably include alfalfa weevil degree-days in their farm or weather reports.
2. Count the number of larvae on a 30-stem sample.
3. Measure the height of 10 stems from the original 30.
4. Refer to Recommendation Charts 1 and 2. They provide directions for the entire weevil season. They will tell you either to resample, harvest early, or spray. They will also tell you when the weevil season is over and you no longer need to sample.

Measuring and Recording Temperature

A record of daily high and low temperatures should be kept from January 1 until the end of the alfalfa weevil season. You can obtain this information from the daily newspaper, local weather stations, radio or television information, specialized county Extension information systems, and so on. Once the daily high and low have been obtained, the next step is to convert this information into degree-days (see Table 1). Locate the daily high in the left-hand column. Read across the page until the column for the daily low is located. The number in that column is the number of degree-days accumulated that day at those temperatures. For example, assume that in your newspaper the previous day's high and low temperatures were reported as 65°F. and 46°F. In Table 1, locate 65°F. in the column under daily high, then read across the page until the column for 46°F. is located. In this example, 8 degree-days were accumulated the previous day.

The degree-days used in this program are based on a developmental threshold of 48°F., since at temperatures lower than this little or no weevil development takes place. (Note that the degree-days used to calculate alfalfa weevil development are not the same as the degree-days quoted in weather reports.) If you live in an area where alfalfa weevils lay eggs in the fall and winter (southern Illinois), your field sampling must begin when a total of 200 degree-days has accumulated since January 1. In areas with no fall or winter egg laying, sampling need not begin until 400 degree-days have accumulated. Your County Extension Adviser can tell you if you have fall egg laying in your area.

A simple chart (see Figure 1) can be used to tally degree-day accumulation and remind you when to begin sampling. According to Figure 1, a total of 107 degree-days had accumulated by the morning of April 28. On the morning of April 29, the previous day's high and low temperatures of 75°F. and 38°F. were obtained from a weather report and recorded. At this high/low combination, 11 degree-days were accumulated, and the total accumulation as of the morning of April 29 was 118 (107 degree-days plus 11 degree-days). The process continues until the termination of the alfalfa weevil season in late spring or early summer.

You may not want to bother with recording degree-days from January 1 until late spring or early summer. Figure 2 shows various zones of expected degree-day accumulation by a given date. You may wish to delay degree-day calculation until the date indicated for your zone and assume that you have accumulated the number of degree-days listed.

Date	Daily high	Daily low	Degree-days	Total degree-day accumulation
1-1	40	25	0	0
1-2	36	32	0	0
1-14	54	22	1	1
4-27	67	41	8	97
4-28	72	40	10	107
4-29	75	38	11	118

Figure 1. Sample record of degree-day accumulation.

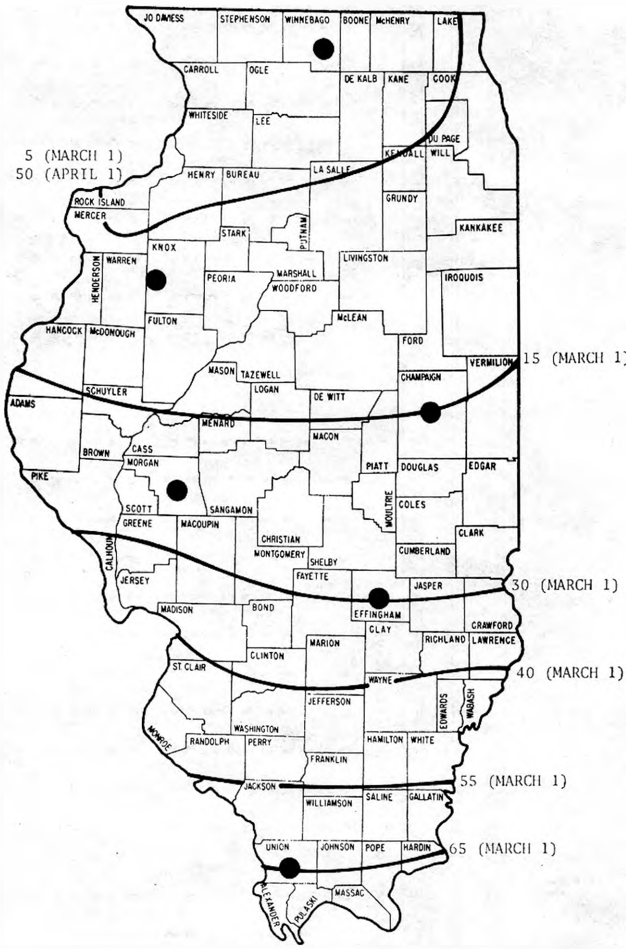

Figure 2. Zones of expected degree-day accumulation by the date indicated (based on a 10-year average). You will have to estimate degree-day accumulations for areas between the lines. Black dots indicate locations of weather stations used to develop the zones.

Counting Larvae and Measuring Plant Height

Each time you take the 30-stem sample in a field, walk through it as illustrated in Figure 3, or in a similar pattern that allows you to sample as much of the whole field as possible. This is important because the level of infestation varies across a field. For example, the problems will often be worse on southern slopes because these areas tend to be more protected during the winter and will warm up sooner in the spring. Avoid field edges because they will give you inaccurate samples. If possible, stay at least 50 feet from the edges.

At 30 evenly spaced intervals, carefully pick an entire stem (without dislodging any larvae) and place it in a 2- to 3-gallon container. Stems at each location must be selected at random, and this can be done by picking the first stem the hand touches. Next, beat the 30 stems vigorously against the inside of the container for a few seconds. Transfer the larvae to a shallow pan for counting and record the number you find. Randomly select 10 stems from the original 30 and record their average length to the nearest inch.

Table 1. Degree-Day Values

High	Low temperature																																								
temperature	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
45-50	When daily high is 50 degrees or less, the degree-day value is 0.																																								
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
52	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
53	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
54	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
55	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
56	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
57	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
58	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
59	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4
60	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4
61	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5
62	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5
63	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	6
64	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6
65	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6
66	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	7	7	7	7
67	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7
68	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	8	8	8
69	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8
70	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	9	9
71	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	9	9	9	9	9
72	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	10	10
73	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	10	10	10	10	10
74	7	7	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	11
75	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	11	11	11	11
76	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	11	11	11	11	11	11	12
77	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	12	12	12	12
78	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	12	12	12	12	12	13
79	9	9	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	12	12	12	12	12	12	13	13	13
80	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	13	13	13	13	13	14
81	9	9	9	10	10	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	13	13	13	13	13	13	14	14	14
82	10	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	14	14	14	14	15
83	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	14	14	14	14	14	15	15	15
84	11	11	11	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	14	14	14	14	14	14	15	15	15	15	15
85	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	14	14	14	14	14	14	15	15	15	15	15	16	16	16
86	11	11	11	12	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	14	15	15	15	15	15	16	16	16	16	16
87	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	14	14	15	15	15	15	15	15	16	16	16	16	16	17	17
88	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	14	14	15	15	15	15	15	15	15	16	16	16	16	16	17	17	17	17	17
89	12	13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	14	14	14	15	15	15	15	15	15	15	16	16	16	16	16	16	17	17	17	17	17	18	18
90	13	13	13	13	13	13	13	13	14	14	14	14	14	14	14	14	14	15	15	15	15	15	15	15	15	16	16	16	16	16	16	16	17	17	17	17	17	18	18	18	18

Table 1. Continued

High	Low temperature																																								
temperature	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
45	0	0	0	0	0	0																																			
46	0	0	0	0	0	0	0																																		
47	0	0	0	0	0	0	0	0																																	
48	0	0	0	0	0	0	0	0	0																																
49	0	0	0	0	0	0	0	0	1	1																															
50	0	0	0	0	1	1	1	1	1	2	2																														
51	1	1	1	1	1	1	1	1	2	2	3	3																													
52	1	1	1	1	1	1	2	2	2	3	3	4	4																												
53	1	1	2	2	2	2	2	2	3	3	4	4	5	5																											
54	2	2	2	2	2	2	2	3	3	4	4	5	5	6	6																										
55	2	2	2	2	3	3	3	3	4	4	5	5	6	6	7	7																									
56	3	3	3	3	3	3	3	4	4	5	5	6	6	7	7	8	8																								
57	3	3	3	3	3	4	4	4	5	5	6	6	7	7	8	8	9	9																							
58	3	3	4	4	4	4	4	5	5	6	6	7	7	8	8	9	9	10	10																						
59	4	4	4	4	4	5	5	5	6	6	7	7	8	8	9	9	10	10	11	11																					
60	4	4	5	5	5	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12																				
61	5	5	5	5	5	6	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13																			
62	5	5	5	6	6	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14																		
63	6	6	6	6	6	7	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15																	
64	6	6	6	7	7	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16																
65	6	7	7	7	7	8	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17															
66	7	7	7	8	8	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18														
67	7	8	8	8	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19													
68	8	8	8	8	9	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20												
69	8	9	9	9	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21											
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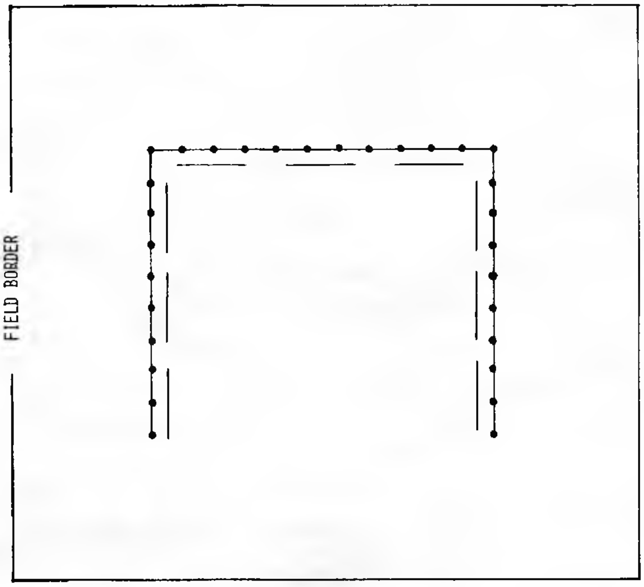

Figure 3. Sampling pattern in a 10- to 15-acre field. Dots indicate the approximate locations of stems used to make the 30-stem sample.

This process requires 20 to 25 minutes for a 15- to 20-acre field. In very large fields (40 acres or more), you may want to take two or more 30-stem samples and then average the results.

Decision Making

Each time you finish sampling an alfalfa field, consult Recommendation Chart 1 or 2 to determine if spraying is needed. For example, if during your first sampling of the season (200 degree-days) you find 44 larvae on alfalfa that averages 3 inches tall, Chart 1 tells you to resample in 50 degree-days. If you find 47 or more larvae when you resample (250 degree-days) and the alfalfa averages 5 inches tall, Chart 1 tells you to spray.

Rarely will you be able to sample at the exact time (degree-day accumulation) that the chart recommends. We suggest that you try to sample within a range of 10 degree-days before or after the recommended time. But if you take your sample closer to midway between recommended sampling times (for example at 225 degree-days), you should average the chart entries to determine what action to take. Assume that you sample 4-inch alfalfa at 225 degree-days; you should spray if you find 53 or more larvae (the average of 67 and 39 is 53).

You should resample a field 100 degree-days after spraying to make sure that the spray was effective. Some confusion may occur, however, if you spray between recommended sampling times. Assume that you take a sample at 250 degree-days and Chart 1 tells you to spray. Assume also that 265 degree-days accumulate by the time you are ready to spray. If you sample the alfalfa 100 degree-days later (365 degree-days), you will be sampling between two recommended sampling times (350 degree-days and 400 to 500 degree-days in Chart 1). In this situation, take your sample at 350 instead of 365 degree-days even though it is a little early. In other words, use the recommended sampling time closest to the "suggested" sampling time.

The portion of Chart 1 from 400 to 500 degree-days covers a larger range. You should still sample, however, at intervals of 50 or 100 degree-days (for example, at 400, 450, and 500 degree-days). Whether you sample 50 or 100 degree-days after 400 degree-days accumulate will depend on alfalfa plant height and larval numbers.

After 550 degree-days have accumulated, the height of the alfalfa has very little effect on the recommended action. At this stage, whether the numbers of weevil larvae are increasing or decreasing is more important. Assume that you sample at 500 degree-days and you find 40 larvae on 12-inch alfalfa. Chart 1 tells you to resample in 50 degree-days. At 550 degree-days you must consult Chart 2. If you find 55 larvae when you resample (550 degree-days), the weevil population has increased by 15 larvae from the previous sample at 500 degree-days. Look in the right-hand column ("Increased 10 or more") to determine the recommended action. In this instance, Chart 2 tells you to harvest or spray. If instead you had found 70 larvae on 16-inch alfalfa at 500 degree-days and you found 55 larvae when you resampled at 550 degree-days, the weevil population would have decreased by 15 larvae. The recommended action in this column ("Decreased 10 or more") is to resample in 50 degree-days. These two examples illustrate how identical population levels (55 larvae) at 550 degree-days can result in different recommendations.

Insecticide Use

Timely and proper use of pesticides is an important part of pest management. Recommendations for 550 degree-days to harvest (see Chart 2) list harvest as a possible alternative to spraying. If you choose to spray at this time, the preharvest waiting period for various insecticides is a very important part of the selection process. Cooperative Extension Circular 899, *Insect Pest Management Guide — Field and Forage Crops,* lists the preharvest interval for insecticides recommended for alfalfa weevil control in Illinois. This information can also be found on the insecticide label. **Always read the label before using any pesticide.**

Postharvest Sampling

Sampling or examining an alfalfa field after the hay has been cut is very important. Both adults and larvae will feed on the alfalfa stubble and developing buds, and the new growth may be delayed or halted. Adults may damage regrowth by "bark-feeding" on the side of the stem, and leaf damage shows up as a feathering on the leaf margins.

You should watch an alfalfa field just after harvest.

Alfalfa Weevil Pest Management Recommendation Chart 1

Number of larvae collected from a 30-stem sample

Total degree-days (*dd*)	Alfalfa height (inches) 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18 or more
200																	
Resample in 50 *dd*	0-26	0-46	0-66	0-84	0-99	0-114	0-129										
SPRAY	27	47	67	85	100	115	130										
250																	
Resample in 50 *dd*	0-20	0-29	0-38	0-46	0-54	0-61	0-68	0-68	0-68								
SPRAY	21	30	39	47	55	62	69	69	69								
300																	
Resample in 50 *dd*		0-24	0-36	0-51	0-66	0-74	0-82	0-93	0-104	0-104	0-104						
SPRAY		25	37	52	67	75	83	94	105	105	105						
350																	
Resample in 100 *dd*					0-13	0-13	0-13	0-13	0-13	0-13	0-16	0-16	0-16	0-16	0-16		
Resample in 50 *dd*					14-81	14-81	14-81	14-81	14-81	14-81	17-81	17-81	17-81	17-81	17-81		
SPRAY					82	82	82	82	82	82	82	82	82	82	82		
400-500																	
Resample in 100 *dd*[a]										0-7	0-7	0-7	0-13	0-13	0-15	0-17	0-17
Resample in 50 *dd*										8-51	8-51	8-57	14-63	14-67	14-71	18-75	18-79
SPRAY										52	52	58	64	68	72	76	80
550 to harvest	(See Chart 2)																
100 after harvest																	
Resample in 100 *dd*[b]	0-16	0-16	0-16	0-19	0-22	0-22	0-22										
Resample in 50 *dd*	17-22	17-32	17-42	20-47	23-52	23-57	23-62										
SPRAY[c]	23	33	43	48	53	58	63										
150 or more after harvest	(See Chart 2)																

[a]If this field was sprayed more than 7 days ago, you can wait 200 degree-days to resample.
[b]If last preharvest sample had less than 30 larvae, the weevil season is over and you can quit sampling.
[c]See section on "Postharvest Sampling."

Alfalfa Weevil Pest Management Recommendation Chart 2

Number of larvae collected from a 30-stem sample

Total degree-days (*dd*)	Change in number of larvae since last sample: Decreased 10 or more	Within 10	Increased 10 or more
550 to harvest			
Resample in 100 *dd*[a]	0-22	0-17	0-12
Resample in 50 *dd*	23-72	18-62	13-52
Harvest or SPRAY	73	63	53
150 or more after harvest			
Quit sampling	0-27	0-17	
Resample in 50 *dd*	28-77	18-57	0-47
SPRAY	78	58	48

[a]If sprayed more than 7 days ago, you can wait 200 degree-days to resample.

If the second-cutting growth does not begin in 2 or 3 days and weevils are still present, apply an insecticide immediately. Begin sampling 100 degree-days after harvest to make sure that larval numbers are not high enough to retard growth of the new crop.

Sampling Frequency

You will take samples more frequently early in the season than toward the end of the season. Expect to visit a field an average of every 7 days during the weevil season. With an extremely early spring, a field could be sampled as many as 11 times or more.

A sample that is preceded by frost or beating rains can result in underestimation of population density. Numerous larvae may be found on the ground following these weather conditions. Although some larvae will probably fail to crawl up the plant, it is suggested that these kinds of fields be resampled the following day.

SUMMARY

This program is offered as an alternative for deciding when to spray alfalfa weevils. One frequently used method relies on percent tip-feeding for deciding whether to spray. This "rule-of-thumb" method varies greatly among observers, so it has some drawbacks. It is, however, better than using no threshold at all. Nevertheless, the program described in this circular should provide you with better and more precise weevil control. The use of this program will also improve timing of control measures, help you avoid serious yield losses, and assure that you use insecticides only when necessary.

Although the Alfalfa Weevil Pest Management Program has received extensive testing and has been used successfully for 3 years by Illinois farmers, it should be remembered that it is a continuing program that will receive further testing, revision, and refinement. With this in mind, it is offered to the farmer, pest management consultant, dealer, and other interested persons as a program to compare with existing indirect methods of determining timing of insecticide application for control of alfalfa weevil.

For further information on this subject, contact the Office of Agricultural Entomology, University of Illinois at Urbana-Champaign, 172 Natural Resources Building, 607 E. Peabody Drive, Champaign, Illinois 68120 (telephone 217-333-6652).

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The authors thank and acknowledge Mr. Wilbur D. Smith, Washington County Extension Adviser, for locating alfalfa fields used during the trial phases of this program and for providing administrative assistance. They also thank the growers who let them use their alfalfa fields during the research phase of this program.

Community Mosquito Control

A community can best handle mosquito problems when an organized abatement district (tax-supported) is established. Qualified personnel with adequate funds can then be hired to conduct an effective mosquito-control program. Illinois Law, Mosquito Abatement Districts Act [Chapter 111-1/2, Section 82 (9) Illinois Revised Status, 1965] enables voters, by referendum, to organize tax-supported abatement districts.

Otherwise, community leaders must direct and implement the program themselves, and few communities have persons who are qualified to direct an effective mosquito-control program. This fact sheet is intended to assist communities that are not part of an established abatement district. Professional advice can be obtained by contacting the Illinois Department of Public Health, Bureau of Environmental Health, 535 West Jefferson Street, Springfield; the University of Illinois, Extension Entomology Office, 172 Natural Resources Building, 607 E. Peabody, Champaign; or your local county Cooperative Extension Adviser. In addition, the following facts about mosquitoes and suggestions for their control should be helpful.

FACTS ABOUT MOSQUITOES. Mosquitoes develop in water. Depending on the species the adult female lays her eggs on standing water or in places that later become flooded. Lakes and ponds with deep water and clean margins (without vegetation and stagnant pools) and flowing water in streams and rivers are not usually sources of mosquito breeding. Mosquitoes can be classed into two breeding-site types: (1) floodwater or temporary pool and (2) standing water. Knowing what species of mosquito is present will help in providing effective control.

Floodwater and temporary pool mosquitoes common to Illinois, include *Aedes vexans* (the inland floodwater mosquito), *Aedes sollicitans* (the saltmarsh mosquito), and *Psorphora confinnis* (the black rice-field mosquito). The eggs of these mosquitoes, which are laid singly on damp soil, require a drying period and may remain dormant for months, hatching within minutes after being covered by water. *Aedes vexans* breeds in areas subject to flooding, such as marshy areas, low wetlands, or poorly drained areas, and is the most important pest mosquito in the state. *Aedes sollicitans* is found chiefly in southern Illinois in association with improper handling of sulphuretted wastes from strip mines and salt water from oil-field operations. *Psorophora confinnis* and other closely related species will develop in very temporary pools, roadside ditches, shallow depressions, and even wheel and animal tracks that fill up during rains.

Floodwater and temporary-pool mosquitoes will complete their development from egg to adult in 8 to 10 days—having several generations a season if there is adequate rainfall to flood or innundate their egg-laying sites. Heavy populations occur in 7 to 14 days after the egg-laying sites are flooded. The adults are obnoxious biters and will bite anytime of the day if disturbed. They are strong flyers. Over a period of days, they may migrate several miles from their breeding sites. These factors make the floodwater mosquitoes a very serious pest in Illinois.

An important intermediate type between the floodwater and standing-water mosquitoes is the tree-hole mosquitoe. In Illinois, *Aedes triseriatus* is a serious pest of wooded areas. Eggs are laid singly just above the water line in tree holes and hollow stumps, which are filled with leaf litter and other organic debris. As rainfall fills the tree holes and stumps and covers the eggs, the larvae hatch and have a life cycle similar to *Culex pipiens* (the northern house mosquito). *Aedes triseriatus* is readily disturbed and will bite anytime during the daylight hours.

Other mosquitoes, such as *Culex pipiens* (the northern house mosquito), *Culex restuans* (a bird feeder, which is important in maintaining St. Louis encephalitis in bird populations), and *Anopheles quadrimaculatus* (the malaria mosquito) are often more abundant in dry seasons. They develop in overgrown ponds, stagnant and shaded pools, poorly managed waste-effluent lagoons, catch basins, puddles in drainage ditches, and in artificial containers such as old tires, tin cans, children's toys, bird baths, eave troughs, and the like. These mosquitoes lay their eggs on the surface of the water singly or in groups (rafts). The mosquito larvae become full grown in about 7 to 10 days and feed on bits of organic matter in the water. The pupae transform into adults in 3 to 4 days. The adult female is ready to bite in another day or two, remaining near the breeding site in order to feed.

In addition to their irritating bite, mosquitoes can transmit diseases, such as California *(Aedes triseriatus)* and St. Louis *(Culex pipiens)* encephalitis, and malaria *(Anopheles quadrimaculatus)* to man; and heartworms to dogs *(Culex pipiens)*.

Generally, the peak biting periods of mosquitoes occur just before and after dark, and again just before dawn. However, each species has its own peak period of biting activity. Male mosquitoes do not bite, but feed on the nectar of flowers and plant juices. At other times, outside the biting periods, adult mosquitoes can be found resting in grass, shrubbery, or other foliage.

SUGGESTIONS FOR CONTROLLING MOSQUITOES IN A COMMUNITY.

1. *Determine the Species Present.* Monitor mosquito populations during the summer with light traps, biting counts, and so on.

2. *Locate Breeding Sites.* Locate and record on a map mosquito breeding sites both within and for at least 5 miles (preferably 15 miles) outside the city. Outlying breeding sites (flooded areas) must be managed for successful suppression of floodwater *(Aedes)* mosquitoes. Continue to watch for new breeding sites or sites overlooked in the initial survey.

3. *Eliminate Breeding Sites.* Make short-term and long-term plans to eliminate as many of these breeding sites as possible by leveling, filling, and draining. Pay particular attention to drainage ditches, catch basins, grassy depressions and low-land areas. Consideration should be given to the importance of wetland areas as wildlife habitats.

4. *Clean Water Margins.* Remove vegetation and debris along the margins of ponds, lakes, and streams and fill or drain back-water pockets. Do not allow vegetation to overhang the water. Mow the grasses and weeds along the margin

frequently. Stock the water with top-feeding minnows belonging to the genus *Gambusia*. Check at your local State Department of Conservation Office (usually located in the county seat) for a source of supply of *Gambusia* minnows.

5. *Use Insecticides as a Supplement to Cultural Practices.*

To control mosquito larvae or wigglers. Check for the presence of mosquito larvae with a white enameled drinking cup. Apply an insecticide treatment to stagnant water areas when numerous larvae are found. Repeated treatments will be needed during periods of mosquito abundance. A single treatment should stop the emergence of new mosquitoes for 10 to 14 days. Use one of the larvicides suggested in Table 1.

To control mosquito adults (for emergency relief when adult mosquitoes are numerous), apply a fog or ULV to grass, weeds, and shrubs; along wooded areas, ditches, roadsides, and parking lots; and in parks and playgrounds (Tables 2 & 3). Fogs kill only those mosquitoes hit by the chemical. Their effect is of short duration, usually a matter of 5 to 20 minutes. *Fogging is best done in the evening just before or just after dark* when mosquitoes are most active and when atmospheric conditions are such that the fog will remain near the ground. Do not apply the treatment if the air temperature is below 60° F. *Fogging at other times of the day* has a psychological benefit but *does not eliminate as many adult mosquitoes.* Repeated treatments will be needed, and their frequency will depend on the effectiveness of the larval-control program. *A control program aimed at only the adult mosquitoes is rarely satisfactory since not all the adults are killed and additional ones are produced or rapidly move back into the treated areas.*

Table 1. Larvicides for Use on Mosquito-Breeding Water

Insecticide and formulation	Pounds of actual insecticide per acre of water	Rate and method of application
Flit MLO	...	Spray over water at 1 to 5 gallons per acre. Use the heavier rate in water high in organic matter.
Bacillus thuringiensis var. *israelensis*	...	Follow label directions.

Type of application equipment to use. Thermal fog generators are available for applying fogs. Ultra-low volume (ULV) applicators are available, or existing equipment can sometimes be adapted to apply the undiluted concentrate as a fine aerosol or cold fog at less than 16 fluid ounces per acre. Power sprayers or small hand-operated tank sprayers can be used to apply larvicides and to spray catch basins. Commercial applicators must hold a current Illinois Custom Spray Applicator's License designated for mosquito control.

Precautions. KEEP THE PUBLIC INFORMED of the activities being planned and conducted for mosquito control. Before any insecticide applications are made, notify the public of the date and time of applications. Individuals with severe allergy conditions and persons with asthmatic problems may wish to stay indoors or plan to be away from the community during the treatment hours. Car finishes may be spotted

Table 2. Ultra-Low-Volume Applications for Control of Adult Mosquitoes

Insecticide and formulation	Pounds of actual insecticide per acre	Rate and method of application[a]
Malathion 9.3 pounds per gallon, 91-percent technical (ULV)	.45	Apply 1 to 2 fluid ounces/minute at vehicle speed of 5 mph. Maximum flow rate of 1 gallon/hour.
		Apply 2 to 4.2 fluid ounces/minute at vehicle speed of 10 mph. Maximum flow rate of 2 gallon/hour. Dose = .66 fluid ounce/acre.

[a]ULV machines should be properly calibrated before the insecticide is applied. All applications to be made based on a 300-foot swath.

Table 3. Fogs for Control of Adult Mosquitoes

Insecticide and formulation	Pounds of actual insecticide per acre	Application instructions[a]
Malathion (91 percent) 9.33 pounds per gallon, concentrate (fog)	.10	Mix 3.9 gallons to 96.1 gallons of fuel oil. Apply 40 gallons per hour at speed of 5 mph and a swath width of 300 feet.
Malathion (50 to 57 percent) 5 pounds per gallon, emulsifiable concentrate (fog)	.10	Mix 8 gallons to 92 gallons of fuel oil. Apply 40 gallons per hour at speed of 5 mph and a swath width of 300 feet.

[a]Mix a small quantity of insecticide with the fuel oil in the correct proportions to be sure they are miscible before preparing a large quantity. Check the label for specific instructions for the type of oil to use and the suggested cosolvents and sludge inhibitors that might be needed to produce a miscible solution. Keep out of lakes, ponds, and streams.

with certain insecticide sprays and owners may wish to house them in the garage during the treatment hours. The understanding and cooperation of the general public are necessary if the program is to be a success.

For individual homeowners. A fact sheet (NHE-94) on mosquitoes and their control in and around the home is available from the University of Illinois Extention Entomology Office, 172 Natural Resources Building, 607 E. Peabody, Champaign, IL 61820. The combined efforts of individual homeowners to control mosquitoes on their properties can greatly enhance the success of a community in solving mosquito problems.

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1983 Turfgrass Pest Control

WITH THE INTRODUCTION of improved management techniques and new, more effective materials, turfgrass culture has developed into a highly sophisticated technology. Among the new materials are the modern pesticides that control weeds, diseases, and insects. Proper irrigation, mowing, and fertilization practices remain the principal defenses against turfgrass pests; it is sometimes necessary, however to complement turfgrass cultural programs with intelligent selection and use of pesticides.

Pesticide formulations. Pesticides are chemicals that are active against one or more turfgrass pests. These chemicals are generally formulated as liquid concentrates — solutions (S) and emulsifiable concentrates (EC) — wettable powders (WP), and granules (G). Liquid concentrates and wettable powders are usually added to water and applied to the turf with a sprayer. Granular materials can be applied with a fertilizer spreader.

Active ingredients. Pesticides must be accurately applied at correct rates to yield optimum results. Too little may control pests ineffectively; too much may injure the turf. The specific amount of material that should be applied depends upon the concentration of the pesticide (the "active ingredient") in the commercial preparation.

Concentration is usually expressed as a weight per unit volume or as a percent of the commercial preparation. For example, a 50 percent wettable powder is 50 percent active ingredients (a.i.) and 50 percent inert carrier. If the recommended rate of application is 12 pounds a.i. per acre, then 24 pounds of this commercial preparation are required to treat one acre. This is roughly equivalent to ½ pound per 1,000 sq. ft. (43,560 sq. ft. = 1 acre).

Liquid formulations generally list the number of pounds of the active ingredient per gallon (lb. a.i./gal.) on the pesticide label. If the concentration is 4 lb./gal., then one quart of the product is required per acre to supply 1 pound of active ingredient per acre.

Precautions. Pesticides should be stored in their original containers with the label securely attached. Keep them in a cool, dry place that is inaccessible to children, pets, and irresponsible persons. **READ THE LABEL BEFORE USING THE PESTICIDE AND FOLLOW ALL INSTRUCTIONS CAREFULLY.** A few minutes spent studying the information on the label may prevent misuse and needless accidents.

WEED CONTROL

Herbicides are pesticides that control one or more plant species. They may be classified into one of three types — contact, systemic, or soil sterilant — depending upon the nature of their activity on plants.

Contact herbicides kill plant parts covered by the chemical. Paraquat, a contact herbicide, is useful in renovating turfs infested with extensive populations of annual weeds. Because paraquat has low soil residual activity, treated areas may be reseeded soon after chemical application.

Table 1. — Chemical Control of Broadleaf Weeds in Turf

	2,4-D[a]	MCPP[b]	Dicamba[c]	Combination of the three[d]
(S = susceptible; I = intermediate control; R = resistant)				
Black medic	R	I	S	S
Carpetweed	S	I	S	S
Chickweed,				
common	R	S-I	S	S
mouse-ear	R	S-I	S	S
Chicory	S	S	S	S
Daisy, oxeye	I	I	I	I
Dandelion	S	S-I	S	S
Dock, curly	I	I-R	S	S
Ground ivy	I-R	I	S-I	S
Hawkweed	S-I	R	S-I	S
Henbit	I	I	S	S
Knotweed	R	I	S	S
Lambsquarters	S	S	S	S
Mallow, roundleaf	I-R	I	S-I	S
Plantain,				
broadleaf	S	I-R	R	S
buckhorn	S	I-R	R	S
Purslane	I	R	S	S
Red sorrel	R	R	S	S
Speedwell,				
creeping	R	R	R	I
purslane	I	I	I	S
Spurge, prostrate	I-R	I	S-I	S
Thistles	S-I	I	S	I
White clover	I	S	S	S
Wild carrot	S	S-I	S	S
Wild onion	I	R	S-I	S
Woodsorrel, yellow	I	I	I	S
Yarrow	I	I-R	S	S

[a] A basic herbicide for use in combination with one or more of the others for broad-spectrum postemergence control of broadleaf weeds. Standard rate of application is 1 lb./A. Not recommended for use on bentgrass putting greens.

[b] Safe for use on bentgrass putting greens at ½ to 1 lb./A. during cool weather periods. Can apply to general turf at 1 lb./A. with 2,4-D.

[c] A very effective herbicide for broadleaf weed control when combined with 2,4-D or as a 3-way combination. Use at ¼ lb./A. with 2,4-D; use at ⅛ lb./A. with 2,4-D + mecoprop. Do not apply above roots of trees and shrubs.

[d] Premixed combinations of 2,4-D, MCPP, and Dicamba are commercially available (Trimec and Trexsan are two of the many products that are readily available).

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Systemic herbicides, absorbed by plant organs and translocated throughout the plant, may be either *selective,* killing certain weeds without injuring desirable grasses, or *nonselective,* controlling all vegetation. Mecoprop is a selective herbicide used to control broadleaf weeds in turf. Dalapon, a nonselective herbicide, is used to kill perennial weedy grasses such as quackgrass that cannot be controlled by selective herbicides.

Soil sterilants are chemicals that render the soil toxic to all plant life. How long the soil remains sterile depends upon the material used, the rate of application, and the prevailing environmental conditions that affect decomposition of the herbicide in the soil. Soil sterilants have no place in turfgrass management; however, they are useful in preventing plant growth under fences and other areas that are difficult to mow.

Herbicides may be applied to prevent weeds from infesting a turf or to control weeds already present. Bensulide is a *preemergence* herbicide applied in spring to prevent development of crabgrass. Once the weed has germinated, DSMA may be used as a *postemergence* treatment to selectively control the crabgrass invader.

INSECT CONTROL

Insecticides are pesticides that reduce insect populations below levels that are injurious to turf. Although insecticide chemistry is quite varied, most of the commonly

Table 2. — Chemical Control of Weed Grasses in Turf

Weeds	Life length	Herbicide	Rate (lb. a.i. per acre)	Remarks
Annual bluegrass	annual or perennial	benefin (Balan)	3	Apply in early spring and late summer. Do not use on bentgrass putting greens.
		bensulide (Betasan)	10	Apply in late summer before the return of cool weather to prevent development of new plants. Fairly safe for use on bentgrass putting greens.
		DCPA (Dacthal)	12	Apply in early spring and late summer. Do not use on Cohansey or Toronto bentgrass putting greens.
		endothall (Endothal)	¾	Apply during warm weather in late summer to Kentucky bluegrass turf. Repeat in two weeks if necessary. After last application, as annual bluegrass turns brown, overseed with desirable grasses or insert plugs of sod into large bare areas to promote rapid healing. Has little or no preemergence activity.
Crabgrass Foxtails Barnyardgrass	annual	benefin (Balan)	2	Apply before emergence of crabgrass in early spring. Not recommended for use on bentgrass turf.
		bensulide (Betasan)	7.5	Apply before emergence of crabgrass in early spring.
		DCPA (Dacthal)	10	Apply before emergence of crabgrass in early spring. May injure bentgrasses and fine-leaf fescues.
		siduron (Tupersan)	12	Apply before emergence of crabgrass in early spring. Use at half the recommended rate in conjunction with seeding Kentucky bluegrass. May injure some bentgrasses and fine-leaf fescues. Do not use on bermudagrass.
		organic arsenicals (DSMA, MSMA, etc.)	follow labels	Apply soon after emergence of crabgrass. Three applications at 7- to 10-day intervals are usually required. May cause some discoloration of the turf.
Goosegrass	annual	DCPA (Dacthal)	15	Goosegrass is harder to control than crabgrass; complete control is rarely achieved. Better control may result if a second application is made at half rate in early June.
		oxadiazon (Ronstar)	3	Apply before emergence of crabgrass in early spring. Do not use on red fescue or bentgrass. Do not apply to wet turf.
		organic arsenicals (DSMA, MSMA, etc.)	follow labels	Apply soon after emergence. Three or more applications at 7- to 10-day intervals may be required for control. May cause some discoloration of the turf.
Bentgrass Nimblewill Tall fescue Quackgrass Bermudagrass	perennial	amitrole dalapon amitrole + dalapon glyphosate	4 10 2 + 5 2	These give nonselective control. Amitrole and dalapon may persist in the soil for up to 4 and 6 weeks, respectively. Overseeding should be delayed until chemical residues have dissipated. Glyphosate has no residual activity in the soil; repeated treatments may be necessary for complete control.
Nutsedge	perennial	bentazon	1	Treat soon after emergence before new nutlets form. Repeat application as necessary for control, up to a total of 3 lb. a.i. per acre per season.

used materials act as contact poisons. Effective control is dependent upon ensuring contact between the insect and the insecticide. Control of soil-inhabiting insects (such as grubs) is best achieved by drenching the insecticide into the soil, whereas foliar-feeding insects (for example, sod webworms) should be controlled by a foliar spray with no irrigation or rainfall for at least 24 hours afterwards.

Most insecticide applications are for control — the insect is controlled after the early signs of injury have been observed. No single insecticide will control all insect pests found in turf. Identify the specific insect before attempting control with an insecticide. Learn to recognize early signs of insect injury to avoid wide-scale loss of turf.

DISEASE CONTROL

Fungicides are pesticides that kill or inhibit the growth of disease-causing fungi. Depending upon the manner in which they protect plants against infection, fungicides are of two general types: protective-contact and systemic.

Protective-contact fungicides are applied to seed, foliage, or soil to keep disease-causing fungi from entering plants. This kind of fungicide must be applied fairly frequently to turf (7- to 14-day intervals) since mowing and irrigation remove much of the surface chemical soon after application. Relatively high spray volumes (5 gal. water per 1,000 sq. ft.) are required to supply uniform and continuous coverage of the foliage by the fungicide. Adding spreader-stickers (surfactants) to the spray mixture facilitates good foliar coverage. Most of the available fungicides for turf are the protective-contact type.

Systemic fungicides, or chemotherapeutants, are absorbed and distributed within the plant, destroying established infections and controlling certain diseases for several weeks or months. These fungicides are absorbed principally by the roots and hence should be drenched or watered in for best results. Examples of systemic fungicides are benomyl (Tersan 1991), chloroneb (Tersan SP), and etridiazole (Koban).

Table 3. — Chemical Control of Insects

Insect	Insecticide[a]	Formulation[b]	Suggestions
Annual white grubs Ataenius grubs	diazinon trichlorfon (Dylox, Proxol) isofenphos (Oftanol) bendiocarb (Turcam)	EC or G SP or G G WP	Apply as spray or granules to small area and then *water in thoroughly* before treating another small area. Grub damage will usually occur in late August and September. Ataenius grubs occur in June, July, and September.
Cicada killer and other soil-nesting wasps Ants	diazinon	EC or G	Apply as spray or granules and water in thoroughly. For individual nests pour 1% diazinon in nest and seal in with dirt.
Sod webworms	carbaryl (Sevin) diazinon chlorpyrifos (Dursban) trichlorfon (Dylox, Proxol)	WP or G EC or G EC or G SP or G	Webworms usually damage lawns in late July and August. As sprays, use at least 2½ gal. water per 1,000 sq. ft. Do not water for 72 hours after treatment. As granules, apply from fertilizer spreader.
Millipedes and sowbugs	carbaryl (Sevin) diazinon	WP or G EC or G	Spray around home where millipedes or sowbugs are crawling. If numerous, treat entire lawn.
Armyworms Cutworms	carbaryl (Sevin) chlorpyrifos (Dursban) trichlorfon (Dylox, Proxol)	WP or G EC or G SP or G	Apply as sprays or granules. Use 5 to 10 gal. of water per 1,000 sq. ft.
Chinch bugs	chlorpyrifos (Dursban) diazinon trichlorfon (Dylox, Proxol)	EC EC SP	Spray infested areas where chinch bugs are present.
Aphids	acephate (Orthene) malathion	EC EC	Spray grass thoroughly.
Chiggers	diazinon	EC	Spray grass thoroughly.
Slugs	Mesurol	bait	Apply where slugs are numerous. Scatter in grass. For use only in flower gardens and shrubbery beds.

[a] Use one of the insecticides recommended for a given group of insects, being sure to use the proper dosage for the formulation chosen. Follow labels as to correct rate of application.
[b] E.C. = emulsion concentrate; W.P. = wettable powder; G = granules.

Table 4. — Chemical Control of Turfgrass Diseases

Diseases[a]	Principal turfgrasses affected	Normal season and intervals of application	Fungicide preparations (oz. per 1,000 sq. ft.)[b]
Helminthosporium diseases			
Melting-out (*H. vagans*)	Fescues Kentucky bluegrass Ryegrasses	March-June; Sept.-Nov. 7 to 14 days	Acti-dione RZ (1.2 oz.) Acti-dione Thiram (2 to 4 oz.) Acti-dione TGF (2 oz.) Chipco 26019 WP 50% (2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Duosan WP 75% (4 to 6 oz.) Dyrene WP 50% (4 to 8 oz.) Fore WP 80% (4 to 6 oz.) Kromad WP (3 to 6 oz.) Manzate D WP 80% (4 to 8 oz.) PCNB (Terraclor) WP 75% (see label) Tersan LSR WP 80% (4 to 8 oz.) zineb WP 75% (4 to 8 oz.)
Helminthosporium leaf spot (*H. sorokinianum*)	All turfgrasses	June-Sept. 7 to 14 days	
Zonate eyespot (*H. giganteum*)	Bermudagrass Bluegrasses Fescues Ryegrasses	June-Sept. 7 to 14 days	
Helminthosporium blight (*H. dictyoides*)	Bluegrasses Fescues Ryegrasses	March-July 7 to 14 days	
Brown blight (*H. siccans*)	Fescues Ryegrasses	April-June 7 to 14 days	
Leaf blotch (*H. cynodontis*)	Bermudagrass	April-June 7 to 14 days	
Red leaf spot* (*H. erythrospilum*)	Bentgrasses	May-Sept. 7 to 14 days	*Daconil and Chipco 26019 are the only fungicides effective against *H. erythrospilum*.
Fusarium blight (*F. roseum* f. sp. *cerealis* "culmorum" and *F. tricinctum* f. sp. *poae*)	Bentgrasses Bluegrasses Fescues Ryegrasses	May-Sept.	Bayleton WP 25% (4 to 8 oz.) Chipco 26019 WP 50% (4 oz.) Cleary 3336 WP 50% or Fl (4 to 8 oz.) Fungo WP 50% (4 to 8 oz.) Tersan 1991 WP 50% (5 to 8 oz.)
	Comments: Apply when disease is expected or first appears. Repeat in 14 to 21 days if necessary. Drench fungicide into root zone using ½ inch (300 gal.) of water per 1,000 sq. ft. Water the turf thoroughly the day before (300 to 450 gal. water per 1,000 sq. ft.).		
Sclerotinia dollar spot (*S. homoeocarpa*)	All turfgrasses	May-Nov. 7 to 14 days	Acti-dione Thiram (2 to 4 oz.) Acti-dione TGF (1 to 2 oz.) Bayleton WP 25% (1 to 2 oz.) cadmium compounds (see label) Chipco 26019 WP 50% (2 oz.) Cleary 3336 WP 50% or Fl (2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Duosan WP 75% (3 to 6 oz.) Dyrene WP 50% (3 to 8 oz.) Fungo WP 50% (2 oz.) Kromad WP (3 to 6 oz.) Tersan 1991 WP 50% (1 to 2 oz.) thiram WP 75% (4 oz.) Vorlan WP 50% (2 oz.)
Red thread or pink patch (*Laetisaria fuciformis* and *Limonomyces* spp.)	All turfgrasses	April-June; August-Nov. 7 to 14 days	
	Comments: Resistance to cadmium compounds, benomyl, thiophanate materials, Dyrene, and other fungicides has been reported in some areas. Using combinations of active ingredients or alternating between products is advisable.		
Rhizoctonia brown patch (*R. solani*)	All turfgrasses	May-Oct. 5 to 14 days	Bayleton WP 25% (1 to 2 oz.) Chipco 26019 WP 50% (2 oz.) Cleary 3336 WP 50% or Fl (2 to 3 oz.) Daconil 2787 WP 75% or 500 (3 to 11 oz.) Duosan WP (4 to 6 oz.) Dyrene WP 50% (4 to 8 oz.) Fungo WP 50% (2 to 3 oz.) Kromad WP (3 to 6 oz.) Tersan 1991 WP 50% (2 to 3 oz.) thiram WP 75% (4 to 6 oz.)
Rusts: leaf and stem (*Puccinia* spp.)	All turfgrasses, especially certain cultivars of Kentucky bluegrass, Perennial ryegrass, Zoysiagrass, and Bermudagrass	June-Oct. 7 to 14 days	Acti-dione Thiram (4 oz.) Acti-dione TGF (2 oz.) Bayleton WP 25% (1 to 2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Duosan WP 75% (4 to 6 oz.) Dyrene WP 50% (4 to 8 oz.) Fore WP 80% (2 to 4 oz.) Tersan LSR WP 80% (2 to 4 oz.) zineb WP 75% (2 to 4 oz.)

[a] Causal fungus listed in parentheses.

[b] Denotes either fungicide, coined name of that material, or representative trade names. Mention of a trade name or proprietary product does not constitute warranty of the product and does not imply approval of this material to the exclusion of comparable products that may be equally suitable. Except where indicated, all materials should be applied in 3 to 5 gal. of water per 1,000 sq. ft. Use lower fungicide rates in *preventive* programs, higher rates for *curative* programs. Only one from each recommended group of preparations need be used. Fungicide use and restrictions are subject to change without notice. Always read and follow the current package label instructions and precautions.

Table 4. — Chemical Control of Turfgrass Diseases (continued)

Diseases[a]	Principal turfgrasses affected	Normal season and intervals of application	Fungicide preparations (oz. per 1,000 sq. ft.)[b]
Anthracnose (*Colletotrichum graminicola*)	All turfgrasses, especially annual bluegrass	June-Sept. 7 to 14 days	Cleary 3336 WP 50% or Fl (1 to 2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Duosan WP 75% (3 to 6 oz.) Fungo WP 50% (1 to 2 oz.) Tersan 1991 WP 50% (1 to 2 oz.)
Leaf smuts Stripe smut (*Ustilago striiformis*) Flag smut (*Urocystis agropyri*)	All turfgrasses, especially certain bentgrasses, bluegrasses, and ryegrasses	Oct.-Nov.	Bayleton WP 25% (6 to 8 oz.) *plus* PCNB (Terraclor) WP 75% *or* Chipco 26019 WP 50% (6 to 8 oz.) *or* Fungo WP 50% (6 to 8 oz.) Tersan 1991 WP 50% (6 to 8 oz.)
Comments: Make two applications, 14 to 21 days apart. Drench fungicide into soil, using 1 inch (600 gal.) water per 1,000 square ft., immediately after application.			
Powdery mildew (*Erysiphe graminis*)	Bluegrasses Bermudagrass Fescues	April-Nov. 7 to 14 days	Acti-dione Thiram (2 to 4 oz.) Acti-dione TGF (1 to 2 oz.) Cleary 3336 WP 50% or Fl (1 to 2 oz.) Fungo WP 50% (1 to 2 oz.) Tersan 1991 WP 50% (1 to 2 oz.)
Snow molds Typhula blight (*T.* species)	All turfgrasses	Nov.-March see label for interval	Chipco 26019 WP 50% (2 to 4 oz.) Bayleton WP 25% (5 to 8 oz.) Tersan SP WP 65% (6 to 9 oz.) Calo-clor, Calo-Gran (see label)[c] Daconil 2787 WP 75% or 500 (8 to 11 oz.)
Fusarium patch (*F. nivale* or *Gerlachia nivalis*)			Tersan SP WP 65% (6 to 9 oz.) Tersan 1991 WP 50% (5 to 8 oz.) Calo-clor, Calo-Gran (see label)[c] Bayleton WP 25% (5 to 8 oz.) Chipco 26019 WP 50% (2 to 4 oz.)
Pythium blight, grease spot, spot blight (many *P.* species)	All turfgrasses	April-Nov. 5 to 10 days	Banol WP 65.5% (1⅓ to 4 oz.) Koban WP 35% (4 to 8 oz.) Subdue 2E WP 25% (1 to 2 oz.) Terrazole WP 35% (4 to 8 oz.) Tersan SP WP 65% (4 to 6 oz.)
		Comments: Apply fungicide in 10 gal. water per 1,000 sq. ft.	
Fairy rings (*Marasmius oreades, Agaricus* or *Psalliota campestris, Chorophyllum* [*Lepiota*] species)	All turfgrasses		methyl bromide chloropicrin Vapam Soil Fumigant Vorlex formaldehyde
Comments: Soil temperature should be above 60° F. for fumigation. Cover area with gas-proof cover for several days, *or* instead of treating with fungicide, use root-feeder attachment on hose to drench rings with water. Repeat when symptoms reappear.			
Seed rot, damping-off, seedling blights (*Pythium* sp., *Fusarium* sp., *Rhizoctonia solani, Helminthosporium* sp., *Colletotrichum graminicola*)	All turfgrasses	Treat seed before planting.	captan or thiram 50% to 75%, plus Koban WP 35% (see label)
		Spray at early seedling emergence and 7 to 10 days later (see labels)	Koban WP 35% or Tersan SP WP 65% *plus* one of these: captan WP 50% Dyrene WP 50% thiram WP 75% zineb WP 75%
Nematodes (many genera and species)	All turfgrasses	fenamiphos (Nemacur), ethoprop (Mocap, Proturf Nematicide, or fensulfothion (Dasanit): granules.	
Comments: Follow the manufacturer's directions carefully. Follow nematicide immediately with at least ½ inch of water to ensure penetration into soil to prevent toxic effects. Treat in fall or spring (or both, if nematodes are a serious problem) when soil temperature is above 55° F. Aerifying turf before application improves results. *Do not apply to newly seeded areas.* For use only by certified pesticide applicators.			
Slime molds (*Physarum cinereum, Fuligo* sp., *Mucilago spongiosa, Stemonitis* spp.)	All turfgrasses	May-Sept. Mow, rake, pole, or hose down to remove mold when seen. Controlled by any fungicide listed for *Helminthosporium* diseases.	
Algae, green or black scum	All turfgrasses	Apply when first seen; reapply as needed.	copper sulfate (1 to 2 oz.) Daconil 2787 WP 75% or 500 (4 to 11 oz.) Fore WP 80% (4 to 6 oz.) Tersan LSR WP 80% (4 to 6 oz.)
Moss	All turfgrasses	Apply when first seen; reapply as needed.	ferrous ammonium sulfate (16 oz.)

[c] Cleared for use *only* on golf course greens, aprons, and tees by certified golf course superintendents.

WEEDS

1983 Row Crop Weed Control Guide

This guide is based on the results of research conducted by the University of Illinois Agricultural Experiment Station, other experiment stations, and the U.S. Department of Agriculture. Consideration has been given to the soils, crops, and weed problems of Illinois.

Rainfall, soil type, method of application, and formulation influence herbicide effectiveness. Under certain conditions some herbicides may damage crops to which they are applied. In some cases, herbicide residues in the soil may damage crops grown later.

When selecting a herbicide, consider both the risk involved in using the herbicide and the yield losses caused by weeds. If cultivation and good cultural practices are controlling weeds, herbicides may be unnecessary. You can reduce risks by taking these precautions:

- Apply herbicides only to those crops for which use has been approved.
- Clean tanks thoroughly when changing from corn to soybeans, especially when using a postemergence herbicide.
- Use recommended rates. Applying too much herbicide is costly and in addition may damage crops and cause illegal residues. Using too little herbicide can result in poor weed control.
- Apply herbicides only at times specified on the label. Observe the recommended intervals between treatment and pasturing or harvesting of crops.
- Wear goggles, rubber gloves, and other protective clothing as suggested by the label.
- Guard against drift injury to nearby susceptible plants, such as soybeans, grapes, and tomatoes. Mist or vapors from 2,4-D, MCPA, and dicamba sprays may drift several hundred yards. Operate sprayers at low pressure with tips that deliver large droplets. Spray only on calm days or make sure air is not moving toward susceptible crop plants and ornamentals.
- Apply herbicides only when all animals and persons not directly involved in the application have been removed from the area. Avoid unnecessary exposure.
- Check label for proper method of container disposal. Triple rinse, puncture, and haul metal containers to an approved sanitary landfill. Haul paper containers to a sanitary landfill or burn them in an approved manner.
- Return unused herbicides to a safe storage place promptly. Store them in original containers, away from unauthorized persons, particularly children.
- Since manufacturers' formulations and labels are sometimes changed and government regulations modified, always refer to the most recent product label.

This guide has been developed to help you use herbicides as effectively and safely as possible. However, since no guide can remove all the risk involved, the University of Illinois and its employees assume no responsibility for results of using herbicides, even if they have been used according to the suggestions, recommendations, or directions of the manufacturer or any governmental agency.

Cultural and Mechanical Control

Most weed control programs combine good cultural practices, mechanical weed control, and herbicide applications. Good cultural practices to aid weed control include preparation of a good seedbed, adequate fertilization, crop rotation, seeding on the proper date, use of the optimum row width, and seeding at the rate for optimum stands.

Planting in relatively warm soils helps crops compete better with weeds. Good weed control during the first 3 to 5 weeks is extremely important for both corn and soybeans. If weed control is adequate during that period, corn and soybeans will usually compete quite well with most of the weeds that begin growth later.

Narrow rows will shade the centers faster and help the crop compete better with the weeds. However, if herbicides alone cannot give adequate weed control, then keep rows wide enough to allow cultivation. Some of the newer herbicides are improving the chances of adequate control without cultivation.

If a preemergence or preplant herbicide does not appear to be controlling weeds adequately, use the rotary hoe while weeds are still small enough to be controlled.

Use the rotary hoe after weed seeds have germinated but before most have emerged. Operate it at 8 to 12 miles per hour and weight it enough to stir the soil and kill the tiny weeds. Rotary hoeing also aids crop emergence if the soil is crusted.

Row cultivators also should be used while weeds are small. Throwing soil into the row can help smother small

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weeds. Cultivate shallow to prevent injury to crop roots. Avoid excessive ridging; it may hinder harvesting and encourage erosion.

Herbicides can provide a convenient and economical means of early weed control by allowing delayed and faster cultivation. Furthermore, unless the soil is crusted, it is usually not necessary to cultivate at all when herbicides are controlling weeds adequately.

Herbicide Incorporation

Soil-applied herbicides are incorporated to minimize surface loss, reduce dependence upon rainfall, and provide appropriate placement of the herbicide. Sutan+ and Eradicane are incorporated soon after application to minimize surface loss from volatization. Dinitroaniline herbicides such as Treflan and Prowl are incorporated within a few hours to minimize loss due to photodecomposition and volatization. Triazine herbicides such as atrazine and Bladex and acetanilide herbicides such as Lasso and Dual may be incorporated to minimize dependence upon timely rainfall, but time of incorporation for them is less critical since they are not lost so quickly from the soil surface.

Incorporation should place the herbicide uniformly in the top 1 to 2 inches of soil for best control of small-seeded annual weeds that germinate from shallow depths. Slightly deeper placement may improve the control of certain weeds from deep-germinating seed under relatively dry conditions. The field cultivator and tandem disk place most of the herbicide one-half to two-thirds of the depth of operation. Thus for most herbicides the suggested depth of operation is 3 to 4 inches.

Thorough incorporation with ground-drive implements may require two passes. Single-pass incorporation tends to result in streaked weed control, especially in wet soils. Single-pass incorporation may be adequate with some equipment, especially if rotary hoeing and cultivation are used to improve weed control. If the herbicide is sufficiently covered to prevent surface loss with the first pass, the second pass can be delayed until immediately before planting. The addition of a coil-tine or spike-tooth drag harrow or rolling baskets behind the disk or field cultivator can help provide uniform mixing.

The depth and thoroughness of incorporation depend upon the type of equipment, depth and speed of operation, soil texture, and soil moisture. Field cultivators and tandem disks are common implements used for incorporation. However, disk-chisels and other combination tools are being promoted and used in some areas.

Field Cultivators

Field cultivators are frequently used for herbicide incorporation. They should have three or more rows of tool bars with an effective shank spacing of no more than 8 to 9 inches (a spacing of 24 to 27 inches on each of three tool bars). The shanks can be equipped with points or sweeps. Sweeps usually give better incorporation, especially when soil conditions are a little too wet or dry for optimal soil flow and mixing. Sweeps for "C" shank cultivators should be at least as wide as the effective shank spacing.

The recommended operating depth for the field cultivator is 3 to 4 inches. It is usually necessary to operate only deep enough to remove tractor-tire depressions. The ground speed should be at least 6 mph. The field cultivator must be operated in a level position so that the back shanks are not operating in untreated soil, which would result in streaked weed control. Two passes are recommended to obtain uniform weed control. If single-pass incorporation is preferred, the use of wider sweeps or narrower spacing will increase the probability of obtaining adequate weed control.

Tandem Disks

Tandem disk harrows invert the soil and usually place the herbicide deeper in the soil than most other incorporation tools. Tandem disks used for herbicide incorporation should have disk blade diameters of 22 inches or less and blade spacings of 7 to 9 inches. Larger disks are considered primary tillage tools and should not be used for incorporating herbicides. Spherical disk blades give better herbicide mixing than conical disk blades.

Tandem disks usually place most of the herbicide in the top two-thirds of the depth of operation. For most herbicides, the suggested operating depth is from 3 to 4 inches. Recommended ground speeds are usually between 4 and 6 mph. The speed should be sufficient to move the soil the full width of the blade spacing. Lower speeds can result in herbicide streaking.

Chemical Weed Control

Plan your chemical weed-control program to fit your soils, crops, weed problems, and farming operations. Herbicide performance depends on the weather and on wise selection and application. Your decisions on herbicide use should be based on the nature and seriousness of your weed problems.

Corn or soybeans occasionally may be injured by some of the herbicides registered for use on them. However, the benefits from weed control are usually much greater than the adverse effects. Crop tolerance ratings for various herbicides are given in the table on the last page of this publication. Corn or soybeans under stress from soil crusting, depth of planting, or adverse weather are more subject to herbicide injury. Plants injured by a herbicide are likely to be more subject to disease.

Apply the herbicide at the time specified on the label. Select and apply herbicides at the correct rate in order to reduce crop injury. The application rates for most herbicides vary with soil texture and organic matter.

You must also consider the kinds of weeds likely to be present. The herbicide selectivity table at the end of this guide indicates the susceptibility of our most common weed species to herbicides.

Crop planting intentions for the next season must also be considered. Where high rates of atrazine or simazine are used, you should not plant soybeans, small grains, alfalfa, or vegetables the following year. If you are considering planting wheat after soybeans, be sure that the application of Treflan or similar herbicides for soybeans is uniform and sufficiently early to reduce the risk of injury to wheat or corn following soybeans. Refer to the herbicide label for cropping sequence information.

Names of Some Herbicides

Trade	Common (generic)
AAtrex, Atrazine	atrazine
Alanap	naptalam
Amiben	chloramben
Banvel	dicamba
Basagran	bentazon
Basalin	fluchloralin
Bicep	metolachlor + atrazine
Bladex	cyanazine
Blazer	acifluorfen
Bronco	alachlor + glyphosate
Butoxone, Butyrac	2,4-DB
Dowpon M	dalapon
Dual	metolachlor
Dyanap	naptalam plus dinoseb
Eradicane Extra	EPTC
Evik	ametryn
Furloe Chloro IPC	chlorpropham
Fusilade	fluazifop-butyl
Goal	oxyfluorfen
Hoelon	dichlofop
Laddok	bentazon + atrazine
Lasso	alachlor
Lorox	linuron
Milogard	propazine
Modown	bifenox
Paraquat, Gramoxone	paraquat
Poast	sethoxydim
Princep, Simazine	simazine
Prowl	pendimethalin
Ramrod	propachlor
Rescue	naptalam plus 2,4-DB
Roundup	glyphosate
Sencor, Lexone	metribuzin
(several)	2,4-D
Surflan	oryzalin
Sutan+	butylate
Sutazine	butylate plus atrazine
Treflan	trifluralin
Vernam	vernolate
Vistar	mefluidide

Some herbicides have different formulations and concentrations under the same trade name. *No endorsement of any trade name is implied, nor is discrimination against similar products intended.*

Herbicide Combinations

Herbicides are often combined to control more weed species, reduce carryover, or reduce crop injury. Some combinations are sold as a "package mix," while others are tank mixed. Tank mixing allows you to adjust the ratio to fit local weed and soil conditions. If you use a tank mix, you must follow restrictions on all products used in the combination.

Problems sometimes occur when mixing emulsifiable concentrate (EC) formulations with wettable powder (WP), water dispersible liquid (WDL), or water dispersible granule (WDG) formulations. These problems can sometimes be prevented by using proper mixing procedures. Fill tanks at least one-third full with water or liquid fertilizer before adding herbicides. If using liquid fertilizers, check compatibility in a small lot before mixing a tankful. The addition of compatibility agents may be necessary. Wettable powders, WDGs, or WDLs should be added to the tank before ECs. Emulsify ECs by mixing with equal volumes of water before adding them to the tank. Empty and clean spray tanks often enough to prevent accumulation of material on the sides and the bottom of the tank.

Some of the herbicide combinations that have been registered are listed below. The herbicide listed first is the one that carries label or supplemental instructions on mixing. The label of the other herbicide(s) may also have mixing instructions.

Corn

Atrazine + Princep (PPI, Pre, NT/P, NT/R)[1]
Atrazine + propachlor (Pre, early Post)
Banvel + atrazine (Post)
Banvel + Lasso (Pre, early Post)
Banvel + 2,4-D (Post)
Basagran + atrazine (Post)
Bladex + atrazine (PPI, Pre, Post, NT/P)
Bladex + atrazine + Lasso (PPI, Pre)
Bladex + paraquat (NT)
Bladex + Sutan+ (PPI)
Dual + AAtrex (PPI, Pre, early Post, NT/P, NT/R)
Dual + Princep (PPI, Pre, NT/P, NT/R)
Dual + atrazine + Princep (PPI, Pre, NT/P, NT/R)
Dual + Banvel (Pre, early Post)
Dual + Bladex (PPI, Pre, NT/P)
Eradicane + atrazine or Bladex (PPI)
Eradicane + Bladex + atrazine (PPI)
Lasso + atrazine (PPI, Pre, early Post, NT/P, NT/R)
Lasso + Bladex (PPI, Pre, NT/R)
Lasso + Princep (NT/R)
Paraquat + atrazine (NT)
Prowl + atrazine (Pre, early Post)
Prowl + Banvel (Pre)
Prowl + Bladex (Pre, early Post)
Sencor + atrazine + Dual or Lasso (Pre)
Sencor + Bladex + Dual or Lasso (Pre)
Sutan+ + atrazine (PPI)
Sutan+ + atrazine + Bladex (PPI)

Soybeans

Alanap + 2,4-DB (Post)
Amiben + Lasso (PPI, Pre)
Amiben + Lorox (Pre)
Amiben + Sencor (Pre)
Amiben + Surflan (Pre)
Amiben + Treflan or Basalin (PPI)
Amiben + Dual + Sencor or Lexone (PPI, Pre)
Amiben + Lasso + Sencor or Lexone (PPI, Pre)
Amiben + Treflan + Sencor or Lexone (PPI)
Basagran + 2,4-DB (Post)
Basalin + Sencor or Lexone (PPI)
Blazer + 2,4-DB (Post)
Dual + Amiben (PPI, Pre)
Dual + Dyanap (Pre, early Post)
Dual + Lorox (Pre, NT/P, NT/R)
Dual + Sencor or Lexone (PPI, Pre, NT/P, NT/R)
Dyanap + Lasso (Pre, early Post)
Furloe + Lasso (Pre)
Furloe + Treflan (PPI)
Furloe + Vernam (PPI)
Goal + Lasso (Pre, NT/P)
Lasso + Lorox (Pre, NT/P, NT/R)
Lasso + Lexone or Sencor (PPI, Pre, NT/P, NT/R)
Lorox + 2,4-DB (Post — directed)
Modown + Lasso (PPI, Pre)
Modown + Treflan (PPI)
Paraquat + Lorox (NT)
Paraquat + Sencor (NT)
Prowl + Amiben (PPI, Pre)
Prowl + Amiben + Sencor or Lexone (PPI, Pre)
Prowl + Lorox (Pre, NT/P)
Prowl + Sencor or Lexone (PPI, Pre, NT/P)
Sencor + Amiben (Pre)
Sencor + Dyanap (Pre)
Sencor + Lasso + Dyanap (Pre)
Sencor + 2,4-DB (Post — directed)
Sencore or Lexone + Treflan (PPI)
Sencor + Treflan (PPI) + Sencor (Pre)
Surflan + Dyanap (Pre)
Surflan + Lorox (Pre, NT/P)
Surflan + Sencor or Lexone (Pre, NT/P)
Vernam + Treflan or Basalin (PPI)
Vernam + Amiben (PPI)

[1] PPI = preplant incorporated, Pre = preemergence, Post = postemergence, NT = no-till, NT/P = no-till with Paraquat, NT/R = no-till with Roundup.

The user can apply two treatments of the same herbicide (split application), or he can use two different ones, provided such uses are registered. Applying two herbicides at different times is referred to as a sequential or overlay treatment. Sequential treatment can be done in a number of ways. For example, a preplant application might be followed by a preemergence application, or a soil-applied treatment might be followed by a postemergence treatment. One herbicide may be broadcast while the other is banded or directed.

Herbicide Rates

Herbicide rates vary according to the time of application, soil conditions, the tillage system used, and the seriousness of the weed infestation. Sometimes lower rates are specified for preemergence application than for preplant incorporated application. Postemergence rates may be lower than preemergence rates if the herbicides can be applied at either time. Postemergence rates often vary depending on the size and species of the weeds and on whether an adjuvant is specified. Rates for combinations are usually lower than for herbicides used alone.

The rates for soil-applied herbicides usually vary depending on the texture of the soil and the amount of organic matter it contains. For instance, light-colored, medium-textured soils with little organic matter require relatively lower rates of most herbicides than do the dark-colored, fine-textured soils with medium to high organic matter. For sandy soils the herbicide label may specify "do not use," "use a reduced rate," or "use a postemergence rather than soil-applied herbicide," depending on the herbicide and its adaptation and on crop tolerance.

The rates given in this publication are, unless otherwise specified, broadcast rates for the amount of formulated product. If you plan to band or direct herbicides, adjust the amount per crop acre according to the percentage of the area actually treated. Many herbicides have several formulations with different concentrations of active ingredient. Be sure to read the label and make the necessary adjustments when changing formulations.

Postemergence Herbicides

Postemergence herbicides applied to growing weeds generally have foliar rather than soil action. The rates and timing of applications are based on weed size and climatic conditions. Weeds can usually be controlled with a lower application rate when they are small and tender. Larger weeds often require a higher herbicide rate or the addition of a spray additive, especially if the weeds have developed under drouth conditions. Herbicide penetration and action are usually greater when the temperature and relative humidity are high. Rainfall occurring too soon after application (1 to 8 hours, depending on the herbicide) can cause poor weed control.

Translocated (hormone) herbicides can be effective with partial foliar coverage, whereas contact herbicides require complete coverage. Foliar coverage increases as water volume and spray pressure are increased. Spray nozzles that produce small droplets also improve coverage. For contact herbicides, 20 to 40 gallons of water per acre are often recommended for ground application and a minimum of 5 gallons per acre for aerial application. Spray pressures of 30 to 50 psi are often suggested with flat-fan or hollow-cone nozzles to produce small droplets and improve canopy penetration. Such small droplets are quite subject to drift.

The use of a surfactant or crop oil concentrate may be recommended to improve spray coverage. These spray additives will usually improve weed control but may increase crop injury. Spray additives may be needed only under drouth conditions or on larger weeds.

Crop size limitations may be specified on the label to minimize crop injury and maximize weed control. If weeds are smaller than the crop, basal-directed sprays may minimize crop injury because they place more herbicide on the weeds than on the crop. If the weeds are taller than the crop, rope-wick applicators or recirculating sprayers can be used to place the herbicides on the top of the weeds and minimize contact with the crop. *Follow the label directions and precautions for each herbicide.*

Conservation Tillage and Weed Control

Efficient production with any tillage system is highly dependent upon effective weed control. Weed control problems have probably been the primary deterrent to widespread adoption of conservation tillage. However, the availability of a wide spectrum of effective herbicides has made acceptable weed control possible with conservation tillage.

Conservation tillage protects the soil from erosion by leaving the soil surface rough and covered with crop residue. For effective erosion control it is essential that the soil surface be protected in the spring before and after corn or soybeans are planted.

Satisfactory weed control is more difficult with crop residue or clods on the soil surface because (1) the residue or clods may interfere with herbicide distribution or incorporation, (2) most weeds are not deeply buried, resulting in heavier weed infestations, and (3) the roots of perennial weeds are not disturbed as much.

Increased weed pressure coupled with decreased herbicide performance requires better herbicide management. You must exercise greater care in choosing herbicides and application rates. Preemergence herbicides require less secondary tillage than preplant-incorporated treatments, but they are more dependent upon timely rainfall. Soil-applied herbicides may require a higher application rate for satisfactory control with conservation tillage. In any case, do not use a higher rate than indicated on the label instructions. Effective postemergence herbicides may be a logical choice when available, as they depend upon foliar action rather than soil action.

No-Till and Double-Crop

Corn and soybeans are sometimes produced without seedbed preparation, either in last year's crop residue (no-till) or as a second crop after small grain harvest or forage removal (double-crop). The no-till concept of planting has greatly improved the probability of success of double-cropping by conserving soil, soil moisture, and time.

No-till herbicides must control both vegetation existing at planting and seedling weeds that germinate after planting. Existing vegetation may be a perennial grass sod, a legume or legume-grass sod, an annual cover crop, or weeds that emerge in the previous years' crop stubble before planting. If a cutting of forages such as alfalfa or clover is removed before no-till planting, control of sod may be poor, especially if herbicides are applied before regrowth. Labeled applications of 2,4-D, Roundup, or Banvel can improve control of broadleaf perennials when used in registered crops, such as corn or sorghum.

Several precautions should be observed in no-till cropping systems. Crop seed should be planted to the proper depth and adequately covered to avoid possible contact from herbicide sprays. (Several herbicide labels give planting depths necessary to avoid possible injury.) Preemergence applications of the herbicide treatment may give better weed control than preplant applications since the planting process may expose untreated soil containing viable weed seed. The total reliance on chemical weed control and large amounts of crop residue present under no-till cropping systems may require that the higher labeled herbicide rates be used to obtain acceptable weed control. Postemergence herbicides may be needed in no-till soybeans.

Paraquat or Gramoxone (1 or 2 pints per acre) plus a *nonionic* surfactant at ½ pint per 100 gallons of diluted spray is generally used to "knock down" existing foliage before crop emergence. Smartweed, giant ragweed, and fall panicum may not be controlled if they are over 10 to 12 inches high and if no rain occurs to "activate" the residual herbicides. A minimum of 40 gallons or more of spray per acre is suggested to insure adequate coverage of the foliage. *Paraquat and Gramoxone are restricted-use pesticides.*

Roundup (3 pints per acre) should be considered as an alternative treatment for control of the foliage prior to crop emergence in situations where fall panicum, smartweed, or certain perennial weeds are a problem. Roundup can translocate to the roots to give better control of perennials. Use 20 to 30 gallons of spray volume per acre. **Bronco** is a formulated mixture of glyphosate (Roundup) plus alachlor (Lasso). Application rates are 4 to 5 quarts per acre. Do not apply in liquid fertilizers.

No-till Corn

Herbicides registered with paraquat plus atrazine are Dual, Lasso, Princep, and Bladex. Dual plus Princep, atrazine plus Princep, and Bicep are also registered with paraquat. These combinations give better control of annual grasses than atrazine or Bladex plus paraquat.

Herbicides registered with Roundup plus atrazine or Princep are Dual and Lasso. Roundup is also registered with atrazine plus Princep, atrazine plus Princep plus Dual, Lasso plus Bladex, and Bicep for use in no-till corn. Bronco is registered for use with atrazine, Bladex, or Princep. The section entitled "Herbicides for Corn" provides more information on these products.

No-till or Double-Crop Soybeans

Preemergence herbicides registered in soybeans as tank mixes with paraquat (1 to 2 pints per acre) are Lorox, Sencor, or Lexone alone or in combination with Lasso, Dual, Prowl, or Surflan. Goal plus Lasso is also cleared with paraquat. Registered tank mixes with Roundup are Lasso or Dual in combination with Lorox, Sencor, or Lexone. Bronco is registered with Lexone, Lorox, or Sencor. See the section entitled "Herbicides for Soybeans" for more information on these products.

Herbicides for Corn

All herbicides mentioned in this section are registered for use on field corn and also on silage corn unless otherwise specified. Herbicide suggestions for sweet corn and popcorn may be found in Circular 907, *1983 Weed Management Guide for Commercial Vegetable Growers.* Growers producing hybrid seed corn should check with the contracting company or inbred producer about tolerance of the parent lines.

Preplant Incorporation

Preplant application should be made anytime during the 1 or 2 weeks before planting. Incorporation should distribute the herbicide uniformly in about the top 2 inches of soil. Do not apply herbicides too early or incorporate them too deeply.

Sutan+ (butylate) or Eradicane (EPTC) may be applied anytime during the 2 weeks prior to planting. It is best to incorporate them soon after application or preferably as they are being applied. Both herbicides are formulated with a crop safening agent to decrease the risk of corn injury. However, injury can still occur when growing conditions are unfavorable or when certain hybrids are used.

Sutan+ and Eradicane control the seedlings of annual grasses, shattercane, and johnsongrass. Eradicane will suppress wild proso millet.

The suggested rate for these herbicides used alone or in combinations is 4¾ to 7⅓ pints per acre. Use the higher amount on heavy infestations of wild cane or yellow nutsedge or to suppress rhizome johnsongrass (see section on specific weed problems). A lower rate may be used on sandy soils.

You can control broadleaf weeds by tank mixing with atrazine or Bladex or by sequencing with an appropriate postemergence herbicide. The rate for combinations of Sutan+ or Eradicane with atrazine is 1¼ to 2 pounds of atrazine 80W (2 to 3 pints of 4L), while the rate for Bladex is 1½ to 3¾ pounds of Bladex 80W (2 to 6 pints 4L). A combination of atrazine plus Bladex with Sutan+ or Eradicane is also registered.

Eradicane Extra includes an extender (microbial inhibitor) to lengthen weed control when Eradicane has been used the previous year. Herbicide combinations are the same as with Eradicane.

Sutazine+ is a prepacked combination of 4.8 pounds of Sutan+ and 1.2 pounds of atrazine per gallon. Suggested application rates are 7 to 10½ pints per acre.

Preplant or Preemergence Herbicides

Incorporation of the following herbicides is optional depending upon the weeds to be controlled and the likelihood of rainfall. Incorporation of these herbicides should be shallow but thorough.

AAtrex, Atrazine (atrazine), or Princep (simazine) can be applied anytime during the 2 weeks prior to planting, or soon after planting. Preplant incorporation of these herbicides controls weeds more effectively if rainfall is limited. Corn tolerance of atrazine and simazine is good, but carryover to subsequent crops can occur.

Princep controls fall panicum and crabgrass better than atrazine but is less effective in controlling cocklebur, velvetleaf, and yellow nutsedge. Princep is less soluble, but just as persistent, as atrazine. Thus, Princep is usually preplant incorporated. Princep plus atrazine can be used in 1:1 or 2:1 combinations; the total rate is the same as for atrazine used alone.

The rate for atrazine used alone is 2½ to 3¾ pounds of atrazine 80W, 4 to 6 pints of 4L, or 2.2 to 3.3 pounds of AAtrex 90WDG. Atrazine controls annual broadleaf weeds better than it does grasses, and it is often used at reduced rates in tank mix combinations to improve broadleaf weed control. The rate for atrazine in combinations is 1½ to 2 pounds of atrazine 80W, 2 to 3 pints of atrazine 4L, or 1.1 to 1.8 pounds of AAtrex 90WDG. These rates may not provide adequate control of cocklebur, morningglory, and velvetleaf but can reduce the risk of carryover.

You can minimize carryover injury by mixing and applying the herbicides accurately, by applying them early, by using the lowest rates consistent with good weed control, and by tilling the soil thoroughly before planting susceptible crops. The risk of carryover is greater the year after a cool, dry growing season and on soils with pH over 7.3.

If you use atrazine at more than 3 pounds of active ingredient per acre or if you apply after June 10, plant only corn or sorghum the next year. If you use atrazine in the spring and must replant, then plant only corn or sorghum that year. Do not plant small grains, small seeded legumes, or vegetables in the fall or spring. Soybeans planted the year after an application of atrazine can also be affected from carryover, especially if you use Sencor or Lexone.

Bladex (cyanazine) does not persist in the soil as long as atrazine, but atrazine does have the advantage of better corn tolerance. Bladex controls fall panicum and giant foxtail, but not broadleaf weeds, better than atrazine. Bladex can be combined with atrazine at 3:1, 2:1, or 1:1 ratios of Bladex to atrazine (see label for rates). The higher ratios will provide better grass control, while the 1:1 ratio will provide better broadleaf weed control.

Rates of Bladex must be selected accurately on the basis of soil texture and organic matter to reduce the possibility of corn injury. Rates are 1½ to 5 pounds of Bladex 80W, 1.2 to 4 quarts Bladex 4L, or 8 to 27 pounds of Bladex 15G per acre. You can lessen the risk of corn injury by using reduced rates of Bladex in combinations.

Bladex can be tank mixed with Lasso, Dual, Ramrod, or Prowl to improve grass control. The Lasso or Dual combination can be applied immediately before planting or after planting. Do not incorporate the Prowl or Ramrod combinations.

Three-way combinations of Bladex plus atrazine plus Lasso, Dual, Sutan+, or Eradicane are registered. The addition of a limited amount of atrazine should improve broadleaf control without increasing concern about carryover.

Lasso (alachlor) or Dual (metolachlor) can be applied preplant incorporated or at the preemergence stage. Preplant incorporation will improve control of yellow nutsedge and can lessen dependence upon rainfall. Incorporation should distribute the herbicide evenly in the top 2 inches of soil.

Lasso and Dual control annual grasses and help control yellow nutsedge. You can improve broadleaf weed control by using atrazine or Bladex in preplant combinations or by using atrazine, Bladex, or Banvel in preemergence combinations.

Lasso can be applied anytime during the week before planting corn and incorporated evenly into the top 2 inches of soil, or it can be used immediately after planting. The rate is 2 to 4 quarts of Lasso 4E or 16 to 26 pounds of Lasso 15G. Use the higher rate for the soil if you plan to incorporate Lasso.

Dual can be applied anytime during the 2 weeks prior to planting corn and incorporated into the top 2 inches of soil, or it can be used immediately after planting. The rates are 1½ to 3 pints of Dual 8E per acre.

Lasso or Dual plus atrazine can be applied preplant incorporated or after planting until corn is 5 inches tall and grass weeds are no larger than the two-leaf stage. Do not apply with liquid fertilizer after the crop emerges. The suggested rate is 1½ to 2½ quarts of Lasso or 1¼ to 2½ pints of Dual 8E plus 1½ to 2½ pounds of atrazine 80W, 1 to 2 quarts of atrazine 4L, or 1.1 to 2.2 pounds of AAtrex 90WDG. **Dual** is also cleared in a combination with atrazine plus Princep.

Dual and Lasso are both formulated as packaged mixes with atrazine. **Bicep** contains 2½ pounds of metolachlor (Dual) and 2 pounds of atrazine per gallon. The rate is 2 to 4 quarts per acre. **Lasso/atrazine** (flowable) contains 2½ pounds of alachlor (Lasso) and 1½ pounds of atrazine per gallon. The rate is 3½ to 4½ quarts per acre.

Dual or Lasso plus Bladex can be applied prior to planting and incorporated, or they can be applied during the preemergence stage after planting. The rate is 2 to 2½ quarts of Lasso 4E or 1¼ to 2½ pints of Dual 8E plus 1 to 3 pounds of Bladex 80W or 1.6 to 4.8 pints of Bladex 4L. Adjust the rate carefully according to soil texture and organic matter.

Preemergence Herbicides

Banvel (dicamba) plus Lasso or Dual can be applied after planting until corn is 3 inches high, but before grasses reach the two-leaf stage. The addition of Banvel improves control of broadleaf weeds without creating a risk of carryover injury. Banvel may injure corn, especially if recommended rates are exceeded, applications are not accurate and uniform, or if corn is planted too shallow (less than 1½ inches). Do not use this treatment on coarse-textured soils or soils that are low in organic matter. The rate on soils with over 2½ percent organic matter is 1 pint of Banvel plus 2½ quarts of Lasso 4E, or 2 to 2½ pints of Dual 8E per acre.

Ramrod (propachlor) can be applied alone or with atrazine after the corn is planted but before grasses reach the two-leaf stage. Granular formulations should be applied before crop or weeds emerge. Ramrod performs well on soils with over 3 percent organic matter.

Ramrod is irritating to the skin and eyes, so observe label precautions. Corn tolerance is good. It controls annual grasses and pigweed. The rate is 4 to 6 quarts of Ramrod 4L or 20 to 30 pounds of 20G per acre.

Ramrod can be mixed with atrazine or Bladex to improve broadleaf weed control. The rate is either 2½ to 4 quarts of 4L plus 1½ to 2 pounds of atrazine 80W (1.2 to 1.6 quarts of 4L) or 1½ to 2¼ pounds of Bladex 80W (1.2 to 1.8 quarts of 4L) per acre.

Prowl (pendimethalin) is registered only for use on corn after planting. Incorporation of Prowl may result in serious corn injury. Use only where it is possible to cover seed adequately with soil. Prowl can control annual grasses and pigweed and provides some control of smartweed and velvetleaf. You can improve broadleaf weed control by combining Prowl with atrazine, Bladex, or Banvel. Prowl plus atrazine or Bladex may be applied in the early postemergence period before grasses are in the two-leaf stage. These combinations may also help reduce the competition from wild proso millet. However, avoid postemergence application when corn is under stress from cool, wet weather; otherwise, corn injury may result. The rate for such combinations is 1 to 1½ quarts of Prowl 4E. Do not use Prowl plus Banvel on sandy soils or soils with less than 1½ percent organic matter.

Sencor (metribuzin) is registered for preemergence use in corn in three-way combinations. The rate is ½ pound of Sencor 50W, ½ pint of Sencor 4L, or ⅓ pound of Sencor 75DF per acre (¼ pound of active ingredient per acre). Sencor can be used at this rate in combination with Lasso or Dual plus atrazine or Bladex. Applying Sencor at this rate with the atrazine or Bladex may improve velvetleaf control but may also increase the potential for corn injury, especially with Bladex. Do not use this combination on coarse-textured soils, soils containing less than 2 percent organic matter, or soils with a pH of 7.0 or higher.

Postemergence Herbicides

Lasso, Dual, Ramrod, Prowl plus Bladex or atrazine, or Lasso or Dual plus Banvel can be used on corn between the preemergence and very early postemergence stages (see preemergence section). To get satisfactory control apply before grasses reach the two-leaf stage.

Banvel plus atrazine can be applied up to 3 weeks after planting but before annual grasses are 1½ inches high. The rate is ½ pint of Banvel plus 1½ to 2 pounds of atrazine 80W or 1 to 1.6 quarts of atrazine 4L.

Atrazine can be applied before grass weeds are more than 1½ inches high. Many annual broadleaf seedlings are more susceptible than grass weeds and may be treated until they are up to 4 inches tall.

The addition of oil-surfactant mixes or surfactants has generally increased the effectiveness of postemergence atrazine. Crop-oil concentrates (80 percent oil and 20 percent surfactant) are used at the rate of 1 quart per acre. Surfactants are usually added at 0.5 percent of the total spray volume or about 1 pint per acre. Results with the oil-surfactant mixes have generally been better than those with surfactants.

Applications of atrazine and oil sometimes damage corn that has been under stress from prolonged cold, wet weather, or other factors. Do not use more than 2½ pounds of atrazine 80W or 2 quarts of atrazine 4L per acre if you mix with oil or oil concentrate. *Do not* add 2,4-D to the atrazine-oil treatment or severe injury may result. Mix the atrazine with water first and add the oil last. If atrazine is applied after June 10, do not plant any crop except corn or sorghum the next year.

Bladex (cyanazine) can be applied through the four-leaf stage of corn growth but before weeds exceed 1½ inches in height. The rate is 1½ to 2½ pounds of Bladex 80W per acre. *Do not use Bladex 4L,* as it contains oil and can increase the potential for injury. A mixture of Bladex plus atrazine is also registered for postemergence use. Injury to corn may occur under cold, adverse growing conditions. The injury may only be temporary yellowing but can be more severe. Under drouthy conditions certain agricultural surfactants or vegetable oils may be added to Bladex 80W to improve weed control. Do not use petroleum crop oils or apply with liquid fertilizers for postemergence application. Do not apply Bladex postemergence to corn under severe stress.

Banvel or Banvel II (dicamba) can be applied from emergence until corn is 36 inches tall. Banvel can be used at a rate of ½ to 1 pint per acre anytime after emergence until corn is 5 inches high. Banvel II is preferred at 1 pint per acre for applications on corn from 5 to 36 inches tall. The best time to apply is at the first flush of broadleaf weeds and before the corn is 5 inches tall. Banvel should be used in a sequential treatment following a grass herbicide such as Lasso, Dual, or Sutan+. Such timing allows for better crop tolerance than the preemergence treatments with Banvel, it permits application at a higher rate than the later postemergence treatment, and it diminishes the likelihood of significant injury to nearby soybeans.

Banvel should be applied before soybeans in the area are 10 inches high. Soybean yields are seldom reduced when slight injury occurs early. However, yields can be reduced if severe injury occurs when soybeans are blooming or during pod fill. Banvel also can injure other susceptible plants, such as vegetables and ornamentals. Use extreme caution to avoid injury to desirable plants from either contaminated sprayers or drift of Banvel from treated areas.

Banvel II or Banvel may be applied until corn is 3 feet high or until 15 days before tasseling. When spraying near soybeans, do not spray corn after it is 2 feet high. If corn is more than 8 inches high, drop nozzles give better weed coverage, reduce drift, and lessen the chance of crop injury. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn and risk of injury to corn is reduced. The broadcast rate is ½ pint per acre of Banvel or 1 pint per acre of Banvel II.

Do not use Banvel on sweet corn, popcorn, or seed corn. Do not graze or harvest corn for dairy feed before the ensilage (milk) stage.

A mixture of ½ pint of Banvel plus ½ pint of 2,4-D amine (4 pounds per gallon) per acre may present less risk of corn injury than 2,4-D alone. Use drop nozzles on corn more than 8 inches high when using the Banvel-plus-2,4-D mixture.

2,4-D is an economical and effective treatment for controlling many broadleaf weeds in corn. Use drop nozzles if corn is more than 8 inches high to decrease the possibility of injury. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn.

Do not apply 2,4-D to corn from tasseling to dough stage. After the hard dough to dent stage, you can apply 1 to 2 pints of certain 2,4-D's by air or high clearance equipment to control late-germinating broadleaf weeds that may interfere with harvest, or to suppress certain perennial weeds.

The suggested broadcast rate of acid equivalent per acre is ⅙ to ¼ pound of ester formulations or ½ pound of amine. This would be ⅓ to ½ pint of ester or 1 pint of amine for formulations with 4 pounds of 2,4-D acid equivalent per gallon.

The ester forms of 2,4-D can vaporize and injure nearby susceptible plants. This vapor movement is more likely with high-volatile than with low-volatile esters. Spray particles of either the ester or the amine form can drift and cause injury.

Corn is often brittle for 7 to 10 days after application of 2,4-D and thus is susceptible to stalk breakage from high winds or cultivation. Other symptoms of 2,4-D injury are stalk bending or lodging, abnormal brace roots, and failure of leaves to unroll.

High temperature and high humidity will increase the potential for 2,4-D injury, especially if corn is growing rapidly. If it is necessary to spray under these conditions, it may be wise to reduce the rate by about 25 percent. Corn hybrids differ in their sensitivity, and the probability of injury increases when corn is under stress.

Basagran (bentazon) is registered for postemergence use in corn in a manner similar to that for soybeans (see soybean section). Since corn is quite tolerant of Basagran, the addition of a crop-oil concentrate is considered relatively safe. Basagran is also cleared at the rate of 1 to 1½ pints in combination with atrazine at 0.6 to 0.9 pound of 80W, 0.6 to 0.8 pound of 90WDG, or 1 to 1½ pints of 4L per acre. **Laddok** is a formulated mixture of Basagran plus atrazine. The rate is 2.4 to 3.6 pints per acre. Oil concentrate is added at 1 quart per acre for control of annual broadleaf weeds only. The combination is more economical than Basagran alone and will reduce the carryover potential from atrazine alone.

Postemergence Soil-Applied Herbicides

Prowl, Treflan, and Lasso can be applied to the soil as postemergence treatments. It may be necessary to use drop nozzles to avoid interference from corn leaves and ensure uniform application to the soil.

Prowl (pendimethalin) or Treflan (trifluralin) may be applied to the soil and incorporated after field corn is 4 (for Prowl) or 8 (for Treflan) inches high and up to the time of last cultivation. The field should be cultivated to control existing weeds and cover the roots at the base of the corn before application. The herbicide should then be thoroughly and uniformly incorporated into the top inch of soil. Prowl may not need incorporation if irrigation or rainfall occurs soon after application. Prowl can be combined with atrazine.

These treatments may help to control late-emerging grasses such as shattercane, wild proso millet, or fall panicum, which can still cause problems.

Lasso (alachlor) may be used as a soil-applied postemergence treatment in corn grown for seed to help control midseason annual grass weeds. Application should preferably be made after cultivation before weeds emerge and before the crop is 40 inches tall. Lasso plus atrazine is an alternative that can be used anytime from immediately after cultivation until weeds reach the two-leaf stage of growth and corn is 40 inches tall.

Directed Postemergence Herbicides

Directed sprays are sometimes needed for emergency situations, especially when grass weeds become too tall for control with cultivation. However, weeds are often too large for directed sprays to be effective. Directed sprays cannot be used on small corn because a height difference between corn and weeds is needed to keep the spray off the corn. Corn leaves that come into contact with the spray can be killed, and injury may affect yields.

Lorox (linuron) may be applied as a directed spray after corn is at least 15 inches high (free standing) but before weeds are 8 inches tall (preferably not more than 5 inches). Lorox controls grass and broadleaf weeds.

The broadcast rate is 1¼ to 3 pounds of Lorox 50W per acre, depending on weed size and soil type. Add Surfactant WK at the rate of 1 pint per 25 gallons of spray mixture. Cover the weeds with the spray, but keep it off the corn as much as possible. *Consider this an emergency treatment.*

Evik 80W (ametryn) is registered for directed use when corn is more than 12 inches tall and weeds are less than 6 inches tall. Evik should not be applied within 3 weeks of tasseling. The rate is 2 to 2½ pounds Evik 80W per acre (broadcast) plus 2 quarts of surfactant per 100 gallons of spray mixture. Extreme care is necessary to keep the spray from contacting the leaves. *Consider this an emergency treatment.*

Herbicides for Soybeans

Consider the kinds of weeds expected when you select a herbicide program for soybeans, especially when growing soybeans in narrow rows. The herbicide selectivity table (see last page of this guide) lists herbicides and their relative weed control ratings for various weeds.

Soybeans may be injured by some herbicides. However, they usually outgrow early injury with little or no effect on yield if stands have not been significantly reduced. Significant yield decreases can result when injury occurs during the bloom to pod fill stages. Excessively shallow planting may increase the risk of injury from some herbicides. Accurate rate selection for soil type is especially essential for Lorox, Lexone, and Sencor. Do not apply Lorox, Lexone, Sencor, or Modown after soybeans have begun to emerge. Follow label instructions as to rates, timing, incorporation, and restrictions.

Preplant Herbicides

Incorporation is required for Basalin, Treflan, and Vernam. Incorporation is optional for Amiben, Dual, Lasso, Modown, and Prowl when used alone and in some combinations. Dyanap, Lorox, and Surflan should not be incorporated. Incorporation can improve performance if rainfall is limited and may increase the effectiveness of Dual or Lasso in controlling nutsedge. Incorporation should distribute the herbicide evenly in the top 1 to 3 inches of soil. Deep incorporation or very early application of the herbicide can cause significant reductions in weed control.

Dinitroaniline herbicides registered for weed control in soybeans are Basalin, Treflan, Prowl, and Surflan. Basalin and Treflan should be incorporated because of their low solubility and because of surface loss through vaporization and photodecomposition. Incorporation is optional with Prowl, but variable weed control and soybean injury may result from preemergence applications. Do not incorporate Surflan (see preemergence section).

Incorporation should distribute the herbicide evenly in the top 2 to 3 inches of soil (see label for implement settings). A deeper incorporation may improve shattercane and johnsongrass seedling control. Basalin, Prowl, or Treflan may be used for rhizome johnsongrass suppression (see section on specific weed problems).

The dinitroaniline herbicides control annual grasses, pigweed, and lambsquarters and may provide some control of smartweed and annual morningglory. Prowl and Surflan may also partially control velvetleaf. However, acceptable control of most other broadleaf weeds requires combinations or sequential treatments with other herbicides. The dinitroaniline herbicides provide similar weed control, soybean tolerance, and persistence when recommended rates are used.

Soybeans are sometimes injured by dinitroaniline herbicides. Plants that have been injured by incorporated treatments are stunted and develop swollen hypocotyls and shortened lateral roots. Such injuries are not usually serious. Plants injured by preemergence applications develop stem callouses at the soil surface, which can cause lodging and yield loss.

Crops of corn, sorghum, or small grains may be injured if they are grown subsequent to a soybean crop that has been treated with a dinitroaniline herbicide. The symptoms are poor germination and stunted, purple plants with poor root systems. To avoid carryover use no more than the recommended rates. Also, be sure that application and incorporation are uniform. The likelihood of carryover increases with double cropping or late application and after a cool, dry season. Disking or chisel plowing provides for minimal dilution of herbicide residues.

Treflan (trifluralin) can be applied alone anytime in the spring. Combinations with Sencor or Lexone should be applied no more than 2 weeks prior to planting, while combinations with Amiben, Furloe, or Modown should be applied within a few days prior to planting. Incorporate as soon as possible, but do not delay incorporation more than 24 hours (8 hours if soil is warm and moist). The rate is 1 to 2 pints of Treflan 4E or 10 to 20 pounds of Treflan 5G per acre.

Basalin (fluchloralin) can be applied anytime during the 8 weeks (alone) or 1 to 2 weeks (with Sencor or Lexone) prior to planting. Incorporate within 8 hours of application. The rate is 1 to 3 pints Basalin 4E per acre. Basalin can be combined with Sencor or Lexone to improve broadleaf weed control.

Prowl (pendimethalin) can be applied within 60 days (alone) or 7 days (with Sencor or Lexone) prior to planting soybeans or applied after planting (see preemergence). Preplant treatments should be incorporated within 7 days of application. Mechanical incorporation may not be necessary if adequate rainfall occurs. Rates are 1 to 3 pints of Prowl 4E per acre, although rates for combinations with Sencor or Lexone are lower than when the herbicide is used alone.

Sencor or Lexone (metribuzin) plus Basalin, Prowl, or Treflan can be tank mixed and applied within 7 to 14 days of planting. Incorporate uniformly into the top 2 inches of soil. The rate of Sencor or Lexone in these combinations is ½ to 1 pound of 50W, ½ to 1 pint of 4L, or ⅓ to ⅔ pound of 75WDG. Use the normal rate, or slightly less, of the dinitroaniline herbicide (see labels).

A Sencor application can also be split, one part being incorporated with Treflan and the other part applied before emergence. This method requires two applications but can give better broadleaf control and less injury than incorporating the same total amount of Sencor with Treflan in a single application.

Amiben (chloramben) can be incorporated with Basalin, Treflan, or Prowl. The rate is 4 to 6 quarts of Amiben 2S per acre. Amiben can also be applied at the rate of 3 to 5 quarts per acre and incorporated with Treflan plus Sencor or Lexone as a three-way combination.

Vernam (vernolate) controls annual grasses and pigweed. It sometimes provides fair control of annual morningglory, velvetleaf, and yellow nutsedge. Some soybean injury may occur in the form of delayed emergence, stunting, and leaf crinkling. Vernam can be applied within 10 days prior to planting and should be incorporated immediately. The broadcast rate is 2⅓ to 3½ pints of Vernam 7E or 20 to 30 pounds of Vernam 10G per acre. Vernam plus Treflan is labeled at the rate of 1 pint of Treflan plus 2⅓ to 3 pints of Vernam 7E per acre. The combination will reduce the risk of soybean injury, but it may also decrease control of velvetleaf and yellow nutsedge. Other labeled combinations include Vernam plus Amiben, Basalin, or Lasso.

Preplant or Preemergence Herbicides

Lasso (alachlor) or Dual (metolachlor) can be applied to soybeans preplant incorporated or during the preemergence stage. If applied prior to planting, apply Dual anytime within the 2 weeks prior to planting and Lasso within 1 week of planting. If rainfall is limited, incorporation can improve performance and increase yellow nutsedge control. Soybeans are quite tolerant of Lasso or Dual. The first to second trifoliate leaves often appear crinkled with a drawstring effect on the middle leaflet, but these symptoms should not cause concern.

Lasso or Dual controls annual grasses plus pigweed and can help control nutsedge and black nightshade. These herbicides can be combined with Lexone, Sencor, or Amiben (incorporated or preemergence) and with Lorox or Dyanap (preemergence only) to improve broadleaf weed control.

The rate for Lasso is 2 to 4 quarts Lasso 4E or 16 to 26 pounds of Lasso II 15G per acre. The rate for Dual 8E is 1½ to 3 pints per acre. Use the higher amount for the soil when incorporating or when black nightshade or yellow nutsedge are to be controlled. The rate for combinations is about 75 percent of that for the herbicide used alone (see labels).

Amiben (chloramben) can control annual grasses plus many broadleaf weeds in soybeans when used at the full rate. Do not expect control of cocklebur or annual morningglory. Control of velvetleaf and jimsonweed is often erratic. Amiben occasionally injures soybeans, but damage is not usually severe. Injured plants may be stunted and have abnormal, shortened roots. If rain does not occur within 3 to 5 days of an Amiben preemergence application, you should rotary hoe. Amiben is best suited to soils with over 2.5 percent organic matter.

Amiben can be applied alone or with Dual, Lasso, or Prowl as a preplant-incorporated or preemergence treatment. Amiben can also be mixed with Lasso or Dual plus Sencor as a preplant or preemergence treatment. Amiben can be applied as a preemergence treatment with Lorox, Lexone, and Sencor.

The Amiben broadcast rate alone is 20 to 30 pounds of 10G, 4 to 6 quarts of 2S, or 2.4 to 3.6 pounds of 75DS per acre. The Amiben rate in combinations is 3 to 6 quarts of 2S (1.8 to 3.6 pounds of 75DS) per acre. Use the higher rate where black nightshade, velvetleaf, or common ragweed is a problem weed.

Sencor or Lexone (metribuzin) can be applied anytime during the 1 to 2 weeks prior to planting and incorporated with Basalin, Dual, Lasso, Prowl, or Treflan. Incorporation should distribute the herbicide evenly in the top 2 inches of soil. It can be applied preemergence by itself or with Amiben, Dual, Lasso, Prowl, Surflan or Dyanap.

Sencor or Lexone can control many annual broadleaf weeds except annual morningglory. Control of giant ragweed, jimsonweed, and cocklebur is marginal at the reduced rates necessary to minimize soybean injury.

One symptom of soybean injury is yellowing (chlorosis) of the lower leaves at about the first trifoliate stage or later; it may be followed by browning of leaves and death of plants depending upon the severity of the injury. Seedling diseases, weather stress, and atrazine carryover may increase the possibility of soybean injury. Injury may be greater on soils with pH over 7.5. Accurate, uniform application and incorporation are essential.

Adjust rates accurately according to soil conditions. *Do not apply to very sandy soil.* Combinations allow for reduced rates and thus reduce risk of soybean injury. The combination rate of Sencor or Lexone is ½ to 1 pound of 50W, ½ to 1 pint of 4L, or ⅓ to ⅔ pound of 75WDG. You can use the higher amount when you apply this treatment during the preemergence stage, either alone or sequentially after applications of a preplant herbicide. The higher amounts can improve broadleaf control but also increase the risk of soybean injury.

Modown (bifenox) can control pigweed, lambsquarters, and smartweed and provide some control of velvetleaf. Combinations with Treflan or Lasso will improve grass control. Modown 4F rates are 3 to 4 pints per acre when used alone in a preemergence application or preplant incorporated with Lasso or Treflan. For preemergence applications with Lasso, the rate is 2½ to 3 pints per acre. For preplant incorporation, the application should be made within 2 to 3 days of planting, and incorporation should place the herbicides evenly into the top 1 to 2 inches of soil. Do not apply Modown after soybeans begin to emerge.

Soybeans may show stunting from Modown, especially from preemergence use followed by cold, wet soil conditions during early growth stages. Injury symptoms are cupping and crinkling of the first few leaves. Soybean injury is usually not reflected in yield.

Furloe Chloro IPC (chlorpropham) can be preplant incorporated with Treflan or Vernam; or it can be applied preemergence by itself or with Lasso to improve smartweed control. Preplant application should be done within a few days of planting soybeans, and incorporation should distribute the herbicide uniformly in the top 1 to 2 inches of soil. The rate in sequential or tank mix combinations is 2 to 3 quarts of Furloe 4E per acre. Furloe 20G is used preemergence at 10 to 15 pounds per acre.

Preemergence Herbicides

Lorox (linuron) is best suited to silt loam soils that contain 1 to 3 percent organic matter. *Do not apply to very sandy soils.* Lorox controls broadleaf weeds better than grass weeds. It does not control annual morningglory, and control of cocklebur and jimsonweed is variable. Accurate and uniform application, and proper rate selection are necessary to minimize the risk of crop injury. Tank-mix combinations allow the use of a reduced rate of Lorox to decrease the risk of soybean injury, but may also decrease the degree of weed control.

Lorox is registered in tank-mix combinations with Amiben, Lasso, Dual, Prowl, or Surflan to improve grass control. The rate of Lorox in these combinations is 1 to 1½ pounds of Lorox 50W or ½ to ¾ pint of Lorox 4L on silt loam soils with less than 3 percent organic matter.

Surflan (oryzalin) can control annual grasses, pigweed, and lambsquarters if there is adequate rainfall. You should rotary hoe to control emerging weeds if adequate rain does not fall within 7 days after application. Do not use on soils of more than 5 percent organic matter. The rate is 1 to 2 pounds per acre of Surflan 75W (¾ to 1½ quarts 4L) used alone or ⅔ to 1⅔ pounds of Surflan 75W in combinations. Surflan can be tank mixed with Amiben, Lorox, Lexone, Sencor, or Dyanap to improve broadleaf weed control. Surflan may cause stem callousing, which can lead to soybean lodging. Do not allow Surflan to contact the soybean seed.

Prowl can be applied preemergence in combination with Amiben, Lexone, Lorox, or Sencor. When applied to the soil surface, Prowl may cause stem callousing, which can lead to soybean lodging. (See preplant section for more information.)

Dyanap (dinoseb plus naptalam) can be applied to soybeans from the time they are planted until the unifoliate leaves of the seedling unfold and expose the growing point. A tank mix of Dyanap plus Lasso, Dual, or Surflan is registered to improve grass control. Dyanap can also be tank mixed with Lasso plus Sencor. The Dyanap rate is 4 to 6 quarts per acre for preemergence application.

Goal (oxyfluorfen) is labeled for preemergence use in no-till soybeans with paraquat in a two-way combination and with paraquat plus Lasso in a three-way combination. Rates in these combinations are 1 quart of Goal, 1 pint of paraquat, and 2 quarts of Lasso per acre.

Postemergence Herbicides

In the past, most farmers have placed primary emphasis on controlling weeds early with preplant or preemergence applications, and have considered postemergence applications as a backup measure when control from earlier treatments was not adequate. Research suggests, however, that soybean yields will probably not be reduced if weeds are controlled within 3 to 4 weeks after planting. The trend toward reduced tillage could encourage greater emphasis on postemergence treatments.

Postemergence herbicides are most effective when their use is part of a planned program, and when they are applied while the weeds are young and tender. They should not be considered simply an emergency treatment. It is especially important to use timely treatments when using postemergence herbicides in narrow-row soybeans. Postemergence herbicides are often the best choice for controlling certain problem weeds such as cocklebur, annual morningglory, and volunteer corn.

Basagran (bentazon) can control many broadleaf weeds, such as cocklebur, jimsonweed, and velvetleaf. It is weak on pigweed, lambsquarters, and annual morningglory. It can be used for control of yellow nutsedge and Canada thistle but not of annual grasses.

The suggested rate for Basagran is ¾ to 1 quart per acre, depending on weed size and species. Application should be done when weeds are small (2-3 inches) and actively growing. These conditions usually exist when the soybeans are in the unifoliate to second trifoliate stage. Spraying during warm sunny weather can also improve performance. Do not spray if rain is expected within 8 hours. Use a minimum of 20 gallons of water per acre in order to get complete weed coverage. Adding a crop-oil concentrate to Basagran may increase performance, particularly on yellow nutsedge, velvetleaf, and morningglory, but may cause some soybean injury. Morningglory up to 10 inches long can be controlled with the addition of 2 fluid ounces of 2,4-DB with Basagran. Do not add crop oil when mixing with 2,4-DB.

Blazer (acifluorfen) can be used to control annual morningglory, pigweed, black nightshade, and jimsonweed. Under ideal conditions it may also help control small escaped annual grasses. The rate is 2 pints of Blazer 2S per acre when broadleaf weeds are at the 2- to 4-inch stage and actively growing. Cocklebur and morningglory control can be improved with the addition of 2 fluid ounces of 2,4-DB (Butyrac or Butoxone). Application should be made when cocklebur and morningglory are not more than 10 to 12 inches tall or long and soybeans have at least five trifoliate leaves.

Blazer is primarily a contact herbicide. Leaf burn often occurs, but the crop usually recovers within 2 to 3 weeks. Suggested spray volumes are 20 to 40 gallons of water per acre applied with a spray pressure of 40 psi. Surfactants or crop oil concentrates are not recommended with Blazer. Do not spray if rain is expected within 6 hours.

Dyanap (dinoseb plus naptalam) can be applied to soybeans after the second trifoliate leaf opens until beans become 20 inches tall. Two to 3 quarts per acre is recommended for control of cocklebur, jimsonweed, smartweed, and annual morningglory less than 3 inches tall and four quarts per acre if weeds are 3 to 6 inches tall. A split application of 2 quarts at the second trifoliate stage followed by 2 quarts 10 to 14 days later is recommended for severe weed infestations.

Best results are obtained by using high pressure (40 to 60 pounds per square inch) and 8 to 10 gallons of water per acre. Use 5 gallons of water for aerial application. Although leaf burn can occur, the crop usually recovers within 2 to 3 weeks with little or no yield loss. Do not apply Dyanap to wet soybean foliage or if rain is expected within 6 hours. Do not add a surfactant.

Amiben (chloramben) can be applied at 5 to 6 quarts per acre when soybeans are in the cracking to second trifoliate stage of growth. This treatment may control or suppress velvetleaf or smartweed that is less than 4 inches tall.

Alanap (naptalam) plus 2,4-DB can be used for emergency control of cocklebur and giant ragweed. Apply when soybeans are about 18 inches tall but before midbloom stage. Rates are 2 to 3 quarts of Alanap plus 3 to 4 fluid ounces of Butyrac 200 or Butoxone SB per acre. A nonionic surfactant should be added at the rate of 2 quarts per 100 gallons of water. **Rescue** is a formulated mixture of Alanap plus 2,4-DB for use at 2 to 3 quarts per acre. Expect some soybean injury from this treatment. Ground application should be at 10 to 20 gallons of spray volume per acre. Use hollow-cone nozzles positioned 18 to 24 inches above the soybeans or weeds. Maintain spray pressure at 40 to 50 psi.

Hoelon (dichlofop) can control volunteer corn and small annual grass weeds. Application should be made when volunteer corn has all emerged but is less than 10 inches tall. Annual grass weeds should be in the one- to four-leaf stage. The rate for volunteer corn is 2⅔ to 3⅓ pints per acre and for annual grasses is 2 to 3⅓ pints per acre. In most cases use ⅓ gallon of Hoelon per acre. Thorough spray coverage is important, so use a minimum of 20 gallons of water per acre and a minimum spray pressure of 30 psi. Do not tank mix Hoelon with other postemergence herbicides. *Hoelon is a restricted use herbicide.*

Poast (sethoxydim) is a selective postemergence herbicide for grass control in soybeans. It was labeled for experimental use in 1982 and will probably be given full registration in 1983. If registered, Poast can be used at the rate of 1 pint per acre on annual grasses, volunteer corn, and shattercane. Oil concentrate should be used at the rate of 1 pint per acre for aerial application or 2 pints per acre for ground application. Use a minimum of 20 gallons of water per acre with 40 psi pressure for ground application and a minimum of 5 gallons of water for aerial application. Higher water volumes are suggested if grass foliage is dense. Poast may also be used for control of johnsongrass (see section on specific weed problems). Do not tank mix Poast with postemergence broadleaf herbicides as grass control will be reduced.

Fusilade (fluazifop-butyl) is a selective postemergence herbicide for grass control in soybeans. It was labeled for experimental use in 1982 and may be given full registration in 1983. Fusilade is used at the rate of ½ pint per acre on annual grasses up to 10 inches tall and at ¼ pint per acre on volunteer corn up to 36 inches tall. Fusilade will also control johnsongrass (see section on specific weed problems). Oil concentrate should be used at the rate of 1 to 2 pints per acre for ground application and 1 gallon per 100 gallons of water for aerial application.

Vistar (mefluidide) may be used for postemergence control of johnsongrass in soybeans south of Highway I-70 in Illinois. Vistar 2S is used at the rate of 1 pint per acre after the second trifoliate stage of soybeans, and when johnsongrass is less than 15 inches tall. A second application may be necessary 3 to 4 weeks after the first application but no later than 60 days prior to harvest. A nonionic surfactant should be used at the rate of 1 to 2 pints per 100 gallons of spray solution.

Johnsongrass is not immediately killed by Vistar, and usually about 10 days will elapse before the leaves turn brown. Maximum results will be seen in about 3 weeks. Soybeans may also show some injury from Vistar, as indicated by leaf crinkling or slight growth suppression.

Roundup (glyphosate) can be applied through several types of selective applicators — recirculating sprayers, wipers, or rope wicks. This application is particularly useful for control of volunteer corn, shattercane, and johnsongrass. Roundup may also suppress hemp dogbane and common milkweed. Weeds should be a minimum of 6 inches above the soybeans. Avoid contact with the crop. Equipment should be adjusted so that the lowest spray stream or wiper contact is at least 2 inches above the soybeans. For calibration of equipment, refer to Roundup label. For recirculating sprayers and wipers, use the rates given on the label. For rope-wick applicators, mix 1 gallon of Roundup in 2 gallons of water.

Basal-Directed Postemergence Herbicides

Several herbicides have been approved for directed application to the bases of soybean plants for control of late-emerging weeds. The soybeans must be at least 8 inches tall and weeds less than 2 to 4 inches tall. Nozzles must be mounted in a fixed position and accurately adjusted to spray only the lower one-third to one-fourth of the soybean plant. Precise positioning of the spray is essential to prevent serious soybean injury. Special equipment such as oiling shoes or gauge wheels is usually specified. Read the label for correct rates and equipment and for precautions. Some of the herbicides cleared for basal-directed sprays are:

Lorox (linuron) alone or plus 2,4-DB or Premerge
Sencor (metribuzin) alone or plus 2,4-DB
Lexone (metribuzin)
Butoxone SB or Butyrac 200 (2,4-DB)
Paraquat
Premerge
Goal

Most of these herbicides call for application before bloom or the midbloom stage of soybeans. Some of these treatments can be applied a second time.

Basal-directed sprays are not very popular in Illinois because of the special equipment and degree of precision required for application. In Illinois the major weeds in soybeans usually begin growing at the same time and often at about the same rate as the soybeans. Thus it is often difficult to establish a suitable difference in height between the soybeans and weeds unless an early herbicide treatment has been used. If the early treatment is effective, a later directed treatment may not be needed.

Paraquat Harvest Aid

Paraquat and Gramoxone are registered for drying weeds in soybeans just before harvest. For indeterminate varieties (most Illinois varieties), apply when 65 percent of the seed pods have reached a mature brown color or when seed moisture is 30 percent or less. For determinate varieties, apply when at least one-half of the leaves have dropped and the rest of the leaves are turning yellow.

The rate is ½ to 1 pint of Paraquat or Gramoxone per acre. The higher rate is for cocklebur. The total spray volume per acre is 2 to 5 gallons for aerial application or 20 to 40 gallons for ground application. Add 1 quart of nonionic surfactant per 100 gallons of spray. Do not pasture livestock within 15 days of treatment, and remove livestock from treated fields at least 30 days before slaughter.

Herbicides for Sorghum

Atrazine may be used for weed control in sorghum (grain and forage types) or sorghum-sudan hybrids. Application may be made preemergence or postemergence. Plant seed at least 1 inch deep. Do not use preplant or preemergence on soils with less than 1 percent organic matter. Incorporated treatments may show injury if rainfall occurs prior to or shortly after sorghum emergence.

Injury may occur when sorghum is under stress from unusual soil or weather conditions or when rates are too high. The rate of application for preplant and preemergence is 2 to 3 pounds of atrazine 80W per acre. The postemergence rate is 2½ to 3¾ pounds 80W per acre. Rotational crop recommendations and weed control are the same as for atrazine used in corn. Failure to control fall panicum has been a major problem.

Ramrod (propachlor) may be used alone or in combination with atrazine, Milogard, Bladex, or Modown for sorghum. Ramrod will improve grass control, but rates must not be skimpy, especially on soils relatively low in organic matter. For specific rates, consult the label.

Dual (metolachlor) or Dual plus atrazine (or Bicep) can be used on sorghum seed that has had the Concep-seed treatment. These herbicides will improve grass control more than atrazine applied alone.

Milogard (propazine) has better sorghum tolerance than atrazine, but grass control is not as good. Only corn or sorghum may be planted in rotation within 12 months after treatment.

2,4-D may be applied postemergence for broadleaf control in 4- to 12-inch tall sorghum. Use drop nozzles if sorghum is more than 8 inches tall. Rates are similar to those for use in corn (see section on corn herbicides).

Banvel can be applied postemergence until sorghum is 15 inches tall or 25 days after emergence. The rate is ½ pint per acre. Do not graze or feed treated forage or silage prior to the mature grain stage. Sorghum may be injured by Banvel.

Specific Weed Problems

Yellow Nutsedge

Yellow nutsedge is a perennial sedge with a triangular stem. It reproduces mainly by tubers. Regardless of the soil depth at which the tuber germinates, a basal bulb develops 1 to 2 inches under the soil surface. A complex system of rhizomes (underground stems) and tubers develops from this basal bulb. Yellow nutsedge tubers begin sprouting about May 1 in central Illinois. For the most effective control, soil-applied herbicides should be incorporated into the same soil layer in which this basal bulb is developing.

For soybeans, a delay in planting until late May allows time for two or three tillage operations to destroy many nutsedge sprouts. Tillage helps deplete food reserves in nutsedge tubers. Row cultivation is helpful. Preplant applications of Lasso, Dual, or Vernan will also help.

Lasso (alachlor) applied preplant incorporated at 3 to 4 quarts per acre (½ quart more than for surface-applied rates) often gives good control of nutsedge.

Dual (metolachlor) can be applied at 2 to 3 pints of 8E per acre to control nutsedge. Preplant treatment is preferred to treatment at the preemergence stage.

Vernam 7E (vernolate) applied preplant at 3½ pints per acre is also effective against yellow nutsedge. Immediate incorporation is necessary with Vernam.

Basagran (bentazon) is a postemergence treatment that can also help control nutsedge in soybeans. One quart per acre can be applied when nutsedge is 6 to 8 inches tall. A split application (two treatments) of Basagran has also been registered. Addition of a crop-oil concentrate to Basagran may improve performance.

For corn, preplant tillage before nutsedge sprouts is of little help in control. Timely cultivation gives some control, but a program of herbicides plus cultivation has provided the most effective control of nutsedge.

Several preplant treatments are available. **Eradicane (EPTC) or Sutan+ (butylate)** at 4¾ to 7⅓ pints per acre are effective for control of yellow nutsedge in corn. They must be incorporated immediately. **Lasso or Dual** applied in corn as for soybeans can also be quite effective.

The combinations of Lasso, Dual, Sutan+, or Eradicane incorporated with atrazine may give better control of nutsedge while also controlling broadleaf weeds.

Atrazine or Bladex (cyanazine) is used as a postemergence spray to control emerged yellow nutsedge when it is small. Split applications of atrazine plus oil have been more effective than single applications. **Basagran** can be used in corn in a manner similar to that for soybeans. **Lorox (linuron)** directed postemergence spray has also given some control.

Johnsongrass

Johnsongrass can reproduce both from seeds and by rhizomes. Both chemical and cultural methods are needed to control johnsongrass rhizomes.

Much of the rhizome growth occurs after the johnsongrass head begins to appear. Mowing, grazing, or cultivating to keep the grass less than 12 inches tall can reduce rhizome production significantly.

Control of johnsongrass can also be improved with tillage. Fall plowing and disking bring the rhizomes to the soil surface, where many of them are winter-killed. Disking also cuts the rhizomes into small pieces, making them more susceptible to chemical control.

Johnsongrass rhizomes can be controlled or suppressed using certain herbicides in various cropping programs. Several preplant-incorporated herbicides can provide control of johnsongrass seedlings in soybeans or corn (see the table at the end of this publication).

Treflan (trifluralin), Prowl (pendimethalin), or Basalin (fluchloralin) used in a 3-year soybean program has been fairly successful in controlling rhizome johnsongrass. They are used at 1½ to 2 times the normal rate each year for 2 years, and then either at the normal rate, or another suitable herbicide is used the third year before resuming a regular cropping sequence. Thorough preplant tillage and incorporation are necessary for satisfactory control. Be certain not to plant such crops as corn or sorghum following application of these herbicides at the higher rates.

Fusilade (fluazifop-butyl) can control johnsongrass in soybeans. Apply ½ pint per acre when the weed is at most 36 inches tall. A split application of ¼ pint plus ½ pint applied about 3 weeks apart may give better control.

Poast (sethoxydim) can control johnsongrass in soybeans. Apply 1½ pints plus 1 quart crop oil concentrate per acre when the johnsongrass is 24 inches tall. A second application of 1 pint per acre may be required.

Eradicane (EPTC) or Sutan+ (butylate) will suppress rhizome johnsongrass in corn when used at a rate of 7⅓ pints per acre as a preplant-incorporated treatment. However, this increase in rate also increases the risk of corn injury.

Dalapon can be used to treat emerged johnsongrass before planting corn or soybeans. Apply 5 to 7 pounds per acre after the grass is 8 to 12 inches tall. Plow or disk after 3 days and then delay planting corn or soybeans at least 1 week. See the label for specific intervals.

Dalapon can also be used to control johnsongrass after wheat that is not double cropped or undersown with a legume. A combination of mowing, timely dalapon application, and tillage has provided quite effective control.

Roundup (glyphosate) can be used as a spot treatment to control johnsongrass in corn, soybeans, or sorghum. Apply 2 to 3 quarts when johnsongrass has reached the boot to head stage and is actively growing. Use of Roundup in wick or recovery-type sprayers is effective for control of johnsongrass in soybeans. (See section on postemergence herbicides for soybeans.)

Roundup may be applied in small grain stubble when johnsongrass is in the early head stage. Fall applications should be made before the first frost. At least 7 days should be allowed after treatment before tillage.

Quackgrass

Quackgrass is a perennial grass with shallow rhizomes. Most preemergence herbicides will not control it.

Atrazine is quite effective when used as a split application in corn. Apply 2½ pounds of atrazine 80W per acre in the fall or spring and plow 1 to 3 weeks later. Another 2½ pounds per acre should be applied as a preplant or preemergence treatment. Postemergence application is usually less effective. A single treatment with 3¾ to 5 pounds per acre can be applied either in the spring or fall 1 to 3 weeks before plowing, but the split application usually gives better control of annual weeds. If more than 3 pounds of atrazine is applied per acre, plant no crops other than corn or sorghum the next year.

Eradicane (EPTC) can be used to suppress quackgrass in corn where more flexibility in cropping sequence is desired. A rate of 4¾ pints per acre of Eradicane 6.7E can be used on light infestations, while 7⅓ pints per acre is suggested for heavier infestations. There is some risk of corn injury, especially at the higher rate. A tank mix with atrazine should improve control.

Fusilade (fluazifop-butyl) is registered and will be labeled for quackgrass control in soybeans at ¾ pint per acre. Apply when quackgrass is 6 to 8 inches high.

Poast (sethoxydim) can be applied in soybeans at the rate of 2½ pints plus 1 quart of crop oil concentrate per acre when quackgrass is 8 to 12 inches tall. A second application of 1½ pints per acre or a cultivation may be required for season-long control.

Dalapon can be applied to quackgrass 4 to 6 inches tall in the spring at a rate of 8 pounds per acre. Plow after 4 days and delay planting corn for 4 to 5 weeks. Up to 15 pounds of dalapon per acre may be used in the fall.

Roundup (glyphosate) can be used for controlling quackgrass before planting either corn or soybeans. Apply 2 to 3 quarts per acre when quackgrass is 8 inches tall and actively growing (fall or spring). Delay tillage for 3 or more days after application.

Canada Thistle

Canada thistle is a perennial weed that has large food reserves in its root system. There are several varieties of Canada thistle. They differ not only in appearance but also in their susceptibility to herbicides.

2,4-D may give fairly good control of some strains. Rates will depend on where the thistle is growing. For example, higher rates can be used in grass pastures or in noncrop areas than can be used in corn.

Banvel (dicamba) often is a little more effective than 2,4-D and may be used alone or in combination with 2,4-D. Banvel can be used as an after-harvest treatment in wheat, corn, or soybean fields at 2 quarts per acre. Fall treatments should be applied before killing frosts. For best results thistles should be fully emerged and actively growing.

Atrazine and oil applied postemergence has been fairly effective in controlling Canada thistle in corn. Make the application before thistles are 6 inches tall.

Basagran (bentazon) can be used for control of Canada thistle in soybeans or corn when the thistles are 8 to 12 inches tall. Apply ¾ to 1 quart per acre in a single application, or for better control make two applications of ¾ to 1 quart per acre each, 7 to 10 days apart.

Roundup (glyphosate) can be used at 2 to 3 quarts per acre when Canada thistle is at or beyond the early bud stage. Fall treatments must be applied before frost for best results. Allow 3 or more days after application before tillage.

Amitrole or Amitrole-T effectively controls Canada thistle, but can be used only in noncrop areas. **Tordon (picloram)** gives good control of Canada thistle, but soybeans and most other broadleaf plants are extremely sensitive to it. Use only on noncropland.

Black Nightshade

Black nightshade is an annual weed that has become an increasing problem for Illinois soybean growers. The principal problem is caused by the berries, which are about the same size as soybeans at harvest. They contain a sticky juice that can gum up a combine.

Black nightshade does not present much of a problem in corn but should be controlled nonetheless to help reduce production of the weed's seed. Herbicides such as atrazine, Bladex, Banvel, Lasso, and Dual are helpful for controlling this weed in corn.

It can be helpful to plant suspect fields to corn rather than soybeans. If soybeans must be planted, plant suspect fields last. This makes the full strength of the herbicide last longer to help control the midseason flush. Preemergence applications usually maintain control longer than those that are preplant incorporated.

For control in soybeans, Lasso, Dual, or Amiben at full rates or a combination of Amiben or Lorox with Lasso or Dual is helpful. Suspect fields should be monitored and a postemergence application of Blazer considered.

Harvest-aid sprays generally do not solve the problem because they do not make the berries fall before the soybeans are harvested.

Additional Information

Not all herbicides and herbicide combinations available are mentioned in this publication. Some are relatively new and are still being tested. Some are not considered to be very well adapted to Illinois or are not used very extensively. For further information on field crop weed control, consult your county Extension adviser or write to the Department of Agronomy, N-305 Turner Hall, 1102 S. Goodwin Avenue, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801.

Relative Effectiveness of Herbicides on Major Weeds

This chart gives a general comparative rating. Under unfavorable conditions, some herbicides rated good or fair may give erratic or poor results. Under very favorable conditions, control may be better than indicated. Type of soil is also a very important factor to consider when selecting herbicides. Rate of herbicide used also will influence results. G = good, F = fair or variable, and P = poor.

	Grasses									Broadleaf Weeds									
	Crop tolerance	Foxtail	Barnyardgrass	Crabgrass	Fall panicum	Johnsongrass seedlings	Shattercane	Volunteer corn	Yellow nutsedge	Annual morningglory	Cocklebur	Jimsonweed	Lambsquarters	Nightshade, black	Pigweed	Ragweed, common	Ragweed, giant	Smartweed	Velvetleaf
SOYBEANS																			
Preplant																			
Treflan, Prowl, Basalin	F-G	G	G	G	G	G	G	F	P	F-P	P	P	G	P	G	P	P	P-F	P
Sencor, Lexone + dinitroaniline	F	G	G	G	G	G	G	F	P	F	F	F-G	G	P	G	G	F	G	F-G
Vernam	F	G	G	G	G	G	G	F-P	F	F-P	P	P	F	P	G	P	P	P	F
Preplant or Preemergence																			
Amiben	F-G	G	F-G	F-G	F-G	F	F	P	P	P	P	P-F	G	F-G	G	F-G	F	F-G	F
Lasso, Dual	G	G	G	G	G	P-F	P-F	P	F-G	P	P	P	F	F-G	G	P-F	P	P-F	P
Lasso or Dual + Sencor or Lexone	F	G	G	G	G	P	P	P	F	P	F	F-G	G	F	G	F	F	G	F-G
Lasso or Dual + Lorox[1]	F	G	G	G	G	P	P	P	P-F	P	F	F	G	F-G	G	G	F	G	F-G
Lorox[1]	F	F	F	F	F	P	P	P	P	P	F	F	G	F	G	G	F	G	F-G
Modown, Goal	F	F	F	F	F	P	P	P	P	F-P	P	F	G	F	G	F	P	G	F
Sencor, Lexone[1]	F	F	F	F	F	P	P	P	P-F	P	F	F-G	G	P	G	G	F	G	F-G
Postemergence																			
Basagran	F-G	P	P	P	P	P	P	P	F	P-F	G	G	F-P	P	P	F	F	G	F-G
Blazer	F	P-F	P	P-F	P	P	P	P	P	F-G	F	G	F-P	F-G	G	F	F	G	P
Dyanap	F	P	P	P	P	P	P	P	P	F-G	G	G	F-G	P-F	F-G	F	F	F	P
2,4-DB	P-F	P	P	P	P	P	P	P	P	F-G	G	P-F	F	P	F	F	F	P	P
Hoelon	G	G	G	F-P	F	P	P	G	P	P	P	P	P	P	P	P	P	P	P
Poast, Fusilade	G	G	G	G	G	G	G	G	P	P	P	P	P	P	P	P	P	P	P
CORN																			
Preplant																			
Sutan+, Eradicane	F-G	G	G	G	G	F-G	F-G		F-G	P	P	P	P-F	F	G	P	P	P	F
Sutan+ or Eradicane + atrazine, Bladex	F-G	G	G	G	G	F-G	F-G		F-G	F-G	F-G	G	G	G	G	G	F	G	F-G
Princep + atrazine	G	F-G	F-G	F	F	P	P-F		P	F-G	F-G	G	G	G	G	G	G	G	F
Preplant or Preemergence																			
Atrazine	G	F-G	F	P	P	P	P		F	G	F-G	G	G	G	G	G	G	G	F-G
Banvel + Lasso or Dual	F-G	G	G	G	G	P	P		F	P-F	F	F-G	G	G	G	G	F	G	F
Bladex	F-G	F-G	F-G	F-G	G	P	P		P	F	F-G	G	G	G	F	G	F-G	G	F
Bladex + atrazine	F-G	F-G	F	F	F-G	P	P		P	F-G	F-G	G	G	G	G	G	F-G	G	F-G
Lasso, Dual	F-G	G	G	G	G	P-F	P-F		F-G	P	P	P	F	F	G	P-F	P	P-F	P
Lasso or Dual + atrazine or Bladex	F-G	G	G	G	G	P	P		F-G	F-G	F	G	G	G	G	G	F	G	F
Prowl + atrazine or Bladex[1]	F	G	G	G	G	F	F		P	F-G	F	G	G	G	G	G	F	G	F-G
Ramrod + atrazine or Bladex[1]	G	G	G	F-G	F	P	P		P-F	F-G	F	G	G	G	G	G	F	G	F
Ramrod	G	G	F	F-G	F	P	P		P-F	P	P	P	F	P	G	P	P	P	P
Postemergence																			
Atrazine + oil	F-G	F-G	G	P	P	P	P		F	G	G	G	G	G	G	G	F	G	G
Banvel	F-G	P	P	P	P	P	P		P	G	G	G	G	G	G	G	G	G	F
Basagran	G	P	P	P	P	P	P		F	P-F	G	G	F-P	P	P	F	F	G	F-G
Bladex	F-G	G	G	F	F-G	P	P		F	F	F-G	G	F	G	F-G	G	F	G	F-G
2,4-D	F	P	P	P	P	P	P		P	G	G	F	G	F	G	G	G	P-F	F-G

[1] Preemergence only

Weed Control in Small Grains, Forages, and Pastures

In Illinois, only about 5 to 10 percent of the small grain, hay, or pasture acreage is treated for weed control. The worst weed problem in winter wheat is wild garlic in southern Illinois, where 2,4-D is commonly used as a herbicide (see Circular 1109, "Wild Garlic"). Brush species or thistles often occur in pastures, and annual grasses and broadleaf weeds such as chickweed and henbit may be problems in hay crops. Weed control in small grains, forages, and pastures must be a part of a program that includes proper management practices.

Herbicides for Small Grains

Small grains seeded in the fall or early spring often compete very well with most weeds if the stand is good and an appropriate fertilization program is followed. Herbicide suggestions for small grains underseeded with a legume differ from those for small grains growing alone.

2,4-D is used to control certain broadleaf weeds. Winter wheat is more tolerant of 2,4-D than oats, but do not spray wheat in the fall. Small grains can be sprayed in the spring after the plants (wheat or oats) have fully tillered but before they begin rapid stem elongation (usually late March or early April for winter wheat). Spraying in the boot stage may injure the crop and reduce yield. If the small grain is underseeded with a legume, use only the amine formulation of 2,4-D at ½ pint per acre. If there is no legume underseeding, apply 1 pint of 2,4-D amine or ⅔ pint of 2,4-D ester per acre. Ester formulations are suggested for control of wild garlic.

MCPA is less likely to damage oats and legume underseedings than 2,4-D, but it is more expensive and will not control as many different weed species. For small grains underseeded with a legume, use ¼ pound per acre (active ingredient) when the small grain is between the tiller and boot stages, and when legumes are 2 to 3 inches tall.

Banvel (dicamba) should not be used on small grains that have a legume underseeding. It will control wild buckwheat and smartweed better than 2,4-D but is poorer for controlling mustards. It may be used alone or in combination with 2,4-D. Banvel should be applied after winter wheat has fully tillered and before it begins to joint (nodes begin to form in the stem). Do not apply later or lodging and yield reductions can occur. The rate is ¼ pint of Banvel alone or with 4 to 6 ounces of 2,4-D (active ingredient) per acre.

Herbicides for Forage Crops

Weed control in alfalfa and clovers differs according to crop species and type of seeding — crop alone (pure seeding) or in combination with a grass species. Be sure to consult the label for proper use. Alfalfa and most clovers can be established without a companion crop and where there is not a forage grass-legume mixture by using Eptam or Balan.

Seedling Establishment

Eptam 7E (EPTC) is used at a rate of 3½ to 4½ pints per acre and incorporated immediately before planting. It is most effective on grasses and can also give some control of nutsedge, especially at the higher rates.

Balan (benefin) is incorporated at a rate of 3 to 4 quarts per acre, and may be applied up to 10 weeks before planting. Balan will control many annual grasses and some broadleaf weeds.

Butoxone or Butyrac (2,4-DB) can be used postemergence to control broadleaf weeds in alfalfa and most clovers after the companion crop is removed or in legume-only or legume-grass seedings established without a companion crop. Apply when legumes are 2 to 3 inches high and weeds are less than 3 inches high. The rate is 1 to 2 quarts per acre of ester formulations or 1 to 3 quarts of the amine formulation. Do not use ester formulations on most clovers. Do not graze livestock on or cut hay from treated fields within 60 days after treatment on newly seeded stands or 30 days on established stands.

Established Legumes

Princep (simazine) can be applied to pure alfalfa stands established more than 12 months. Apply after the last cutting in the fall. Princep can control many grasses and broadleaf weeds but will not control most well-

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established perennial or biennial weeds. The rate is 1 to 2 pounds per acre of Princep 80W, depending upon soil type. If excessive amounts are used, applications are made at the wrong time, or unfavorable conditions exist, crop injury can occur. Do not graze within 30 days after application or harvest hay within 60 days. *Do not apply on sandy soils or if soil pH is over 7.5.*

Kerb (pronamide) can be applied in the fall to established stands of clover, birdsfoot trefoil, crown vetch, or alfalfa. It will control most annual grass and broadleaf weeds and help suppress quackgrass. Do not apply to mixed stands of legumes and forage grasses. Rates vary from 2 to 4 pounds of Kerb 50W per acre. Do not graze or harvest for forage for at least 120 days following treatment. Kerb is a restricted use herbicide.

Sinbar (terbacil) can be applied to pure stands of alfalfa that are at least a year old. It controls many annual grasses and broadleaf weeds. Apply ½ to 1½ pounds per acre when alfalfa is dormant (fall or spring) but not when the ground is frozen. Injury may result when it is used on certain types of soil (sandy soils with less than 1 percent organic matter) or under unfavorable growing conditions. There is a 2-year waiting period before alfalfa or other crops can be replanted to Sinbar-treated areas.

Sencor or Lexone (metribuzin) can be used in established stands of alfalfa or alfalfa-forage grass mixtures. Higher rates will reduce stands of forage grasses in the mixtures. It should be applied early in the spring before growth begins or in the fall after alfalfa growth ceases. The rate is ¾ to 2 pounds of 50W or ¾ to 2 pints of 4L or ½ to 1.3 pounds of 75DF, depending upon the weed species to be controlled. Do not graze or harvest within 28 days after application.

Paraquat can be applied at 2 to 3 pints per acre to dormant alfalfa to control certain winter annuals and suppress perennial grasses. Apply to well-established stands after the last fall cutting when the crop is dormant or before spring growth reaches 1 inch. Add Ortho X-77 Spreader at 1 to 2 pints per 100 gallons of spray mix. Do not graze, cut, or harvest within 60 days.

Furloe Chloro IPC (chlorpropham) may be applied to pure alfalfa or clover stands that are established or to newly seeded alfalfa with 3 or more trifoliolate leaves. Application for control of chickweed and downy brome may be made from October through January, using 1 to 2 quarts of the 4 EC. Beginning in February, 2 to 3 quarts can be used. Do not apply within 40 days of harvest.

Herbicides for Grass Pastures

Pasture weed control must be part of a total program of good management that includes proper grazing, adequate fertilization, and reseeding as necessary.

2,4-D at ½ to 1 pound per acre should control most broadleaf weeds. Biennial thistles such as bull thistle and musk thistle are most susceptible to 2,4-D in the rosette stage (fall or spring) and when they are actively growing. A higher rate may be needed for the control of more resistant weeds and some perennials. Certain woody species, such as buckbrush and willow, can also be controlled with foliar applications of 2,4-D. Milk cows should not be grazed on treated land for 7 days after treatment.

Banvel (dicamba) can control many broadleaf weeds when used at a rate of 1 to 4 pints per acre. Observe labeled grazing and hay restrictions for lactating dairy cows. Do not use where desirable legumes are present. Avoid injury to other nearby plants that are susceptible to Banvel. Do not graze or harvest for dairy feed until 60 days after treatment. Remove meat animals from treated areas 30 days prior to slaughter.

Multiflora Rose

Multiflora rose is a woody perennial that is spreading into many permanent pastures in Illinois. The plant has numerous sharp thorns along the stems (canes) that prevent livestock from grazing among its canes. Seeds produced by the plant are rapidly spread by wildlife.

Banvel (dicamba) should be applied in early spring when foliage and stems are actively growing but before flower bud formation. Mix 1 gallon of Banvel in 99 gallons of water (3 tablespoons of Banvel per gallon of water). Uniform wetting of stems and foliage is required for best results. Do not allow spray to drift to desirable plants.

Tordon 10K (picloram) can be applied to the soil surface above the active roots of multiflora rose. Uniformly apply 40 pounds of Tordon 10K per acre (3 oz. per 100 square feet). Do not apply above the roots of desirable trees or where runoff may occur or treat over 25 percent of the pasture. *Tordon is a restricted use pesticide.*

Krenite (fosamine) is cleared for noncropland only. Apply Krenite in August and September prior to leaf senescence. Use 1 to 1½ gallons of Krenite plus 1 quart of a nonionic surfactant per 100 gallons of spray to completely cover stems and foliage. Control will not be evident until spring.

Roundup (glyphosate) can be used to control multiflora rose. Apply to actively growing stems and foliage when most plants are at or beyond the early to full bloom stage of growth. Use 2 quarts of Roundup per acre or apply as a 1 percent solution (1 gallon of Roundup per 100 gallons of water) with handheld equipment. Thorough coverage is essential for best results. There is an 8-week grazing restriction when Roundup is used.

Controlling Johnsongrass, Shattercane, and *Sorghum almum* in Illinois

Johnsongrass [*Sorghum halepense* (L.) Pers.] was used as a forage crop in the southern United States before the 1800's. It spread rapidly northward through southern Illinois and is now a problem weed in the state. Johnsongrass has been listed as a primary noxious weed under the Illinois Noxious Weed Law since 1959.

Shattercane [*Sorghum bicolor* (L.)] developed from the natural crossing of diverse sorghum and cultivated sorghum types. Shattercane produces seeds that remain viable in the soil for one or more seasons. Planting wild sorghum contaminated sorghum seedlots has helped spread shattercane in Illinois.

Sorghum almum was introduced to Illinois in the late 1950's as a perennial sudangrass for use as a forage crop. *Sorghum almum* is a hybrid between johnsongrass and a sorghum species belonging to the Arundinacem group. *Sorghum almum* is listed as a perennial member of the sorghum genus under the Illinois Noxious Weed Law.

DESCRIPTIONS

Johnsongrass is a perennial that reproduces by seeds and rhizomes. The root system is a fibrous network of freely branching, fleshy, scaly rhizomes that are white with purple spots. The rhizomes may grow several feet in length and may reach a diameter of 0.75 inch. The stems are erect and smooth, from 3 to 10 feet tall depending on the biotype and environment. The leaves are alternate, simple, and smooth--12 to 30 inches long and 0.70 inch to 1.3 inches wide. Johnsongrass has a large open panicle-type seedhead that is purplish, hairy, and diversely branched. The seeds form in spikelets on the branchlet tips. The seeds are oval with a glossy, mahogany cast. They are 0.13 to 0.15 inch long and are enclosed in straw-colored glumes.

Shattercane is an annual that reproduces by seed. The root system is a well-developed, fibrous network. The stems are erect and smooth, from 3 to 12 feet tall depending on parentage and environment. Several stems may grow from a single crown because the plant readily tillers. The plant closely resembles cultivated sorghum or sudan. Shattercane has a panicle-type seedhead that varies from compact to loose or open. The seeds are oval and are usually enclosed in shiny black-to-dark mahogany glumes. Shattercane seeds closely resemble those of forage sorghum. The seedheads may droop to one side at maturity. The seeds usually shatter before the crop is harvested.

Sorghum almum is a weak perennial that reproduces primarily by seed. However, it may produce plants from overwintering rhizomes. The plants resemble johnsongrass, but have larger and taller stems with wider and longer leaves. The panicle also is longer, spread more, and branched at the whorl. At maturity, the rhizomes usually extend less than 6 inches into the soil profile and closely resemble those produced during the early stage of johnsongrass development. The seed is indistinguishable from johnsongrass seed, making positive identification difficult.

PREVENTION

Johnsongrass, *sorghum almum*, and shattercane are spread by birds, livestock, wind, water, and by contaminated feed, machinery, and crop seed. The seeds remain viable in the soil over a long period of time. Therefore, many areas are continually plagued with new seedlings, even though established plants are controlled.

New johnsongrass and *Sorghum almum* plants also develop from overwintering rhizome buds located at each rhizome node. When rhizome pieces are moved and dropped into clean soil, the area may become infested.

Take the following measures to prevent the spread of seeds and rhizomes:

1. Plant only clean crop seed that is free of johnsongrass, shattercane, and *Sorghum almum* seed.

2. Avoid the introduction of shattercane by planting only pure, cultivated sorghum seed that has been produced under proper isolation to reduce cross-pollination. Cut forage-type sorghums of sorghum-sudan hybrids before the seed matures.

3. Do not bring straw and hay from infested areas into noninfested areas.

4. Do not allow livestock grazing on infested fields to roam into noninfested fields.

5. Clean all machinery--particularly combines where seeds might lodge--before moving it from infested to noninfested fields.

6. Avoid dragging rhizome pieces from infested to noninfested areas with farm implements.

7. Do not let plants develop mature seed.

CONTROL PROGRAMS

The control of johnsongrass, *Sorghum almum*, and shattercane is based on the growth habits of the plants. Effective long-term control involves integrating cultural and chemical methods that prevent seed and rhizome production and reduce the number of viable seeds in the soil.

WINTER GRAIN AND FALLOW PROGRAMS

Winter grain production followed by summer fallow effectively prevents the production of seeds and rhizomes and reduces their number in the soil. Once the small grain is harvested, clean plow and disk thoroughly. To control johnsongrass, repeat the diskings at two- to three-week intervals to keep emerging plants from initiating rhizome spurs.

Tillage destroys weed seedlings and germinating seeds by exposing them to sunlight and desiccation or by covering over them with soil. Cutting rhizomes into small sections and exposing them to drying conditions reduces their viability. Under winter fallow programs, rhizomes near the soil surface will be exposed to below-freezing temperatures. That further reduces rhizome viability.

Where soil erosion is a problem, apply postemergence treatments of dalapon (Dowpon) or glyphosate (Roundup) following small-grain harvest for rhizome and seedling control. Often, a second application is required late in the season to control new rhizome and top growth and prevent seed production (see the accompanying table).

FORAGE, GRAZING, AND MOWING PROGRAMS

Planting a competitive forage crop, such as alfalfa, helps smother-out shattercane, *Sorghum almum*, and johnsongrass seedlings. Frequent harvesting of forage crops, heavy grazing, or repeated mowings also prevent seed production and reduce rhizome vigor. Although pasturing and mowing will not eliminate the weeds, the weakened plants will be more susceptible to other control measures.

Always follow control programs of winter grain, fallow, and forage with an effective seedling-control program after returning to row crops; otherwise, reinfestations of johnsongrass, shattercane, or *Sorghum almum* may occur. Fallowing programs also take land out of production, usually making them economically impractical.

CORN AND SOYBEAN PROGRAMS

Proper soil preparation is critical for effective seedling and rhizome control in row crops. Before incorporating the preplant herbicide, prepare the infested ground by bringing the rhizomes to the surface and cutting them into small pieces. The moldboard plow and the tandem disk work best, but chisel plows and cutting disks also work well in some soil types. Once the large soil clods and excess residues are removed, the field is ready for a preplant-incorporated herbicide treatment (see the table).

Poor control of seedling johnsongrass, *Sorghum almum*, and shattercane usually results from improper herbicide incorporation or from using low herbicide rates. Uniform herbicide distribution is essential for effective control. The tandem disk is often used to incorporate the herbicide. The disk incorporates herbicides at about half the operational depth. Disk twice--preferably with the second disking at an angle to the first--to get a uniform distribution of the herbicide. Therefore, set the disk to cut 4 to 6 inches for the first disking and, at most, 4 inches for the second disking. Do not incorporate the herbicides deeper than 3 inches.

Rotary-hoeing and cultivating are usually required regardless of the preplant-incorporated herbicide treatment employed. Preplant treatments only suppress rhizomes and often allow some seedlings to escape. Time the cultivations carefully. To control johnsongrass, repeat the cultivations at intervals of two to three weeks in order to prevent new rhizome spur growth. Set the cultivator sweeps for shallow cultivation--2 inches or less--and avoid cultivating below the herbicide incorporation depth. Deep cultivation brings untreated soil containing viable seeds to the surface where they can germinate.

Remove scattered plants of johnsongrass, *Sorghum almum*, and shattercane that are not controlled by soil-applied herbicides or cultivation before mature seeds are produced. Rouging, spot treating with glyphosate (Roundup), and recirculating or recovery-type sprayers labeled for use with Roundup are an integral part of the control program, because the plants that escape produce seeds, rhizomes, or both which reinfest the field. Using Roundup in recirculating sprayers, spot treating, and rouging are more effective in soybeans than in corn, because the size of the soybean plants makes seeing and treating the problem grasses easier. Avoid using Roundup in recirculating sprayers for weed control in corn.

Roundup is the only herbicide presently labeled for spot treatment in corn and soybeans. Crop plants sprayed with Roundup will be severely injured, resulting in tissue chlorosis and necrosis.

NON-CROPLAND PROGRAMS

Johnsongrass, *Sorghum almum*, and shattercane plants in fence rows and noncropland areas are a source of new seeds and/or rhizomes. Treat such areas to eliminate the seed source and to prevent field infestations (see the table).

Dalapon (Dowpon) is considered to be an economical herbicide treatment for controlling large infestations of shattercane and *Sorghum almum*. Roundup or dalapon may be the most economical control treatment for infestations of johnsongrass. You may need to retreat heavy johnsongrass infestations to adequately control seedling or rhizome regrowth. Soil sterilants or MSMA will control small johnsongrass patches in non-crop areas, but they may not be economical to use in areas where there are large infestations.

Even after using a good control program for a few years, you may still have a weed problem. Watch for new weeds that grow from old seed left in the soil or from newly introduced seed.

REMARKS

1. Follow the label instructions on incorporation. Thoroughly incorporate the herbicide immediately after application. The treatment is labeled only for seedling control. Destroy emerging plants and break up large clods of soil in the field before the herbicide is applied and/or incorporated. Include a broadleaf herbicide for overall weed control.

2. Clean plowing and disking will cut up the rhizomes in the upper plow layer, reducing their vigor. Increased herbicide rates will only suppress, not control, rhizomes.

3. Apply Roundup to johnsongrass foliage at the early boot stage--minimum, 18 inches tall--or before related sorghum species produce mature seeds. Roundup is a nonselective, systemic herbicide that controls both foliage and rhizomes. Roundup usually kills or injures crop plants and desirable vegetation it contacts. DO NOT MIX, APPLY, OR STORE ROUNDUP SPRAY SOLUTIONS IN GALVANIZED CONTAINERS OR IN UNLINED, STEEL CONTAINERS EXCEPT FOR STAINLESS-STEEL CONTAINERS. DO NOT ADD SURFACTANT TO SPRAY SOLUTIONS.

Type of control	Herbicide and formulation	Rate per acre of formulation	Method of application	Remarks
		CORN		
Johnsongrass	Sutan 6.7E	4-3/4 pints	PPI[a]	1
Sorghum almum	Eradicane 6.7E	4-3/4 pints	PPI[a]	
(seedlings)	Lasso 4E	3-1/2 to 4 quarts	PPI or PRE[b]	
Johnsongrass	Sutan 6.7E	7-1/3 pints	PPI[a]	1, 2
(Rhizome suppression)	Eradicane 6.7E	7-1/3 pints	PPI[a]	
Shattercane (wild cane)				
Johnsongrass Shattercane Sorghum almum (foliage and/or rhizomes)	Roundup 4E	1-1/3 oz. per gal. of water. (1.0% of spray solution)	Foliar spot treatments	3
		SOYBEANS		
Johnsongrass Shattercane *Sorghum almum* (Foliage and/or rhizomes)	Dowpon 85% WP + a surfactant	5 to 8 pounds + a surfactant	Foliar Spring pre-plow treatment	4
Johnsongrass (Foliage and/or rhizomes)	Roundup 4E	2 to 3 quarts	Foliar Spring pre-plow treatment	3, 5
Johnsongrass	Treflan 4E	1-1/2 to 2 pt.	PPI[a]	1
Sorghum almum	Basalin 4E	2 pt.	PPI[a]	
(seedling control)	Prowl	2 to 3 pints	PPI[a]	
	Vernam 7E	3-1/2 pt.	PPI[a]	
	Vernam 10G	30 lb.	PPI[a]	
	Lasso 4E	3-1/2 to 4 qt.	PPI PRE[b]	
Johnsongrass	Treflan 4E	3 to 4 pints	PPI[a]	6, 2
(seedling control and	Basalin 4E	3 to 4 pints	PPI[a]	
rhizome suppression)	Prowl	2 to 4 pints	PPI[a]	
Shattercane	Treflan 4E	2 to 2-1/2 pints		1
(wild cane)	Basalin 4E	2 to 2-1/2 pints		
	Prowl	2 to 3 pints	PPI[a]	
Johnsongrass Shattercane Sorghum almum (Foliage and/or rhizomes	Roundup 4E	1-1/2 ounces per gallon of water (1 percent of solution)	Foliar spot treatment or recirculating sprayer	3

Controlling Johnsongrass, etc (Continued)

Type of control	Herbicide and formulation	Rate per acre of formulation	Method of application	Remarks
		NON-CROPLAND		
BROADCAST TREATMENTS				
Johnsongrass Shattercane Sorghum almum control Heavily infested fields not being cropped or ground fallowed after small grain harvest.	Dowpon 85% WP + a surfactant Roundup 4E	5 to 10 lbs. + surfactant 2 to 3 quarts	Foliar: plants 12-15" tall Foliar: plants 18" tall	7 3, 5
Johnsongrass (non-cropland only)	Asulox	1 gallon	Foliar: plants at least 15" tall	9
SPOT TREATMENTS				
Johnsongrass Shattercane Sorghum almum control Spots and patches on ditchbank, levees, fencerows, wasteland or non-cropland.	Sodium chlorate-modified (salt equivalent with fire retardant)	2 to 4 lbs./100 sq. ft.	Foliar or soil	8
	Sodium TCA 90%	3 to 5 oz./100 sq. ft.	Soil	8
	Dowpon 85% WP + surfactant	1/2 to 1 oz./100 sq. ft. (single treatment)	Foliar: plants 12-15" tall	7
	Roundup 4E	1-1/3 oz. per gal. of water (1% of solution)	Foliar: spot treatment	3
Johnsongrass Shattercane Sorghum almum control (non-cropland only)	Ansar 529 or Daconate (MSMA)	2 quarts 2 quarts	Foliar (point of runoff). Repeat at 1-week intervals as necessary.	9
Johnsongrass (non-cropland only)	Pramitol 25E	4 to 5 1/2 pints/1,000 sq. ft.	Foliar or stubble (through coverage)	8
	Pramitol 5PS	2 lbs./100 sq. ft.	Soil (distribute (evenly)	
	Hyvar X-L (3 lb./gal.)	12 oz./1,000 sq. ft.	Soil or stubble	8
	Hyvar X-WS (50%)	8 oz./500 sq. ft.	Soil (distribute evenly)	8

[a]PPI--preplant and incorporate. [b]PRE--preemergence.

4. Follow the treatment instructions on the label. Use surfactants according to the manufacturer's directions. Broadcast treatments in not less than 40 to 50 gallons of water when the johnsongrass is 12 to 15 inches tall. Plow 3 days later. Wait 5 days after plowing before planting soybeans or corn. If the soil is dry, avoid crop injury by waiting 5 days after a rain of 1/2 inch or more before planting. Two or more diskings to cut up rhizomes are recommended before applying a herbicide for seedling control if a row crop is to be planted. Include a broadleaf herbicide for overall weed control.

5. Broadcast treatments in not less than 20 to 40 gallons of water per acre when the johnsongrass is a minimum of 18 inches tall, but before mature seeds are produced. Plow the ground 7 days later. Corn, soybeans, oats, wheat, barley, or sorghum may be planted following the treatment. Viable weed seeds remaining in the soil will not be controlled. Use a herbicide for seedling control if a row crop is to be planted. Include a broadleaf herbicide for better overall weed control.

6. Follow a tillage program to cut up the rhizomes and destroy the emerging seedling plants before applying the herbicide. Do not plant soybeans until the adverse weather conditions of the early season have passed. Do not plant soybeans deeper than 2 inches. Apply the herbicide at the suggested rates for seedling control and rhizome suppression for two consecutive years. Use good cultural control practices. Reduce the rate to that suggested for seedling control in the third year. Plant only crops labeled for preplant use with these herbicides before rotating to another crop.

7. Follow the label instructions for treatment. Use surfactants according to manufacturer's directions. Broadcast treatments in a minimum of 40 to 50 gallons of water when the johnsongrass is 12 to 15 inches tall. Repeat the treatments a second and and third time at 10- to 15-day intervals as needed, and plow 7 to 14 days after the last treatment. Disk when needed to destroy regrowth from viable weed seeds in the soil. Alfalfa, permanent pasture mixtures, or small grains may be seeded in the fall--3 to 5 weeks after the last treatment.

8. Follow the directions on the label. Treat the soil while problem grasses are small, or mow the older growth to prevent seed production and then treat the soil below the stubble. Repeat the treatments when necessary to destroy regrowth. These materials are short-term soil sterilants. USE ON NON-CROPLAND ONLY. DO NOT GRAZE OR FEED SPRAYED OR TREATED FORAGE TO ANIMALS.

9. Follow the label directions. Use for johnsongrass control on non-cropland only. Viable weed seeds remaining in the soil will not be controlled. DO NOT CONTAMINATE DOMESTIC WATERS USED BY LIVESTOCK, WILDLIFE, AQUATIC LIFE. DO NOT CONTAMINATE IRRIGATION WATER. DO NOT GRAZE OR FEED TREATED FOLIAGE TO LIVESTOCK. Complete coverage of the foliage is necessary. Do not allow the spray solution to run off the foliage. It may take several weeks before the plants die. Do not mow for 4 to 6 weeks after treatment. At recommended rates, Asulox usually will not harm desirable plants, such as tall fescue and perennial bluegrass. Late-season treatments may be more effective.

NOTE: Availability, formulations, trade names, and federal clearances for herbicide use change occasionally. Always refer to the most recent product labels for precautions and for use and rate directions. Apply herbicides carefully to keep from injuring desirable vegetation, wildlife, yourself, and others. Store herbicides properly so children do not have access to them. Store herbicides only in the original, well-marked containers. Dispose of used herbicide containers and old herbicides properly.

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Associate Agronomist

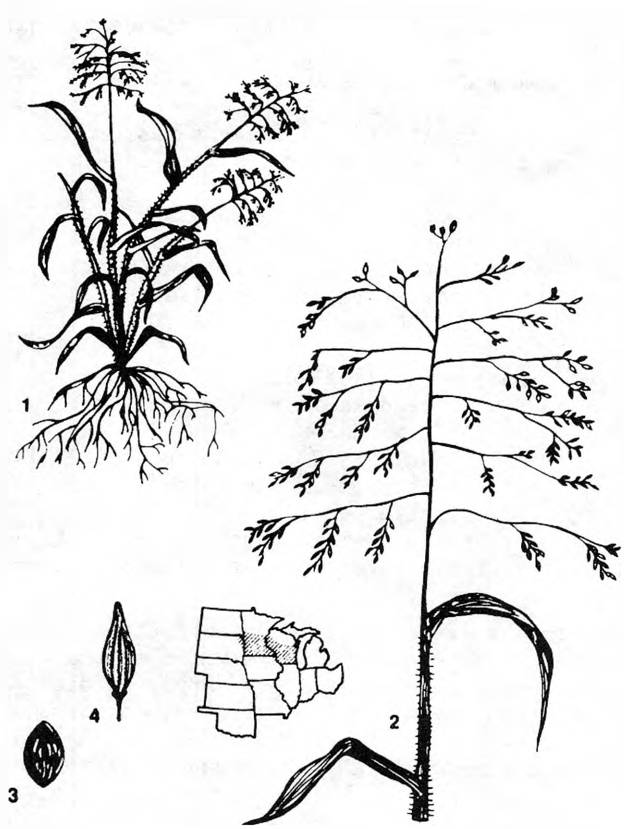
Wild Proso Millet

Wild proso millet (*Panicum miliaceum*) was first recognized as a potential threat to crops during the early 1970s in a few isolated corn fields of southern Wisconsin and southeastern Minnesota. Since then this annual weed has rapidly extended its range into surrounding regions and now appears to be a significant limiting factor in the production of several crops where it has become established. By 1982 wild proso millet had been identified in McHenry, Boone, and Winnebago counties in northern Illinois and may have been present in most of the northern border counties.

The origin of this weed is still a mystery. One possibility is that wild proso millet is an escaped variety of the domestic proso millet, or broomcorn millet, which is often sold in birdseed mixes.

Growth Habit and Identification

In the seedling stage, wild proso millet is often mistaken for volunteer corn and later in its mature stage closely resembles fall panicum (*Panicum dichotomiflorum*). Because it is similar to fall panicum, wild proso millet may not be recognized in many fields until infestations become serious. Many farmers have referred to this weed as a "bionic" fall panicum because of its vigorous growth habits. A light stand of wild proso millet can develop into a severe infestation in a single growing season. The weed is extremely competitive, especially with open-canopy crops such as many vegetables, with sweet corn, and in some seed corn production fields.



WILD PROSO MILLET, Panicum miliaceum *L. 1, entire plant; 2, enlarged section of upper stem with panicle; 3, seed; 4, seed with hull.*

Wild proso millet is particularly well adapted to sandy and droughty soils. It can reach maturity in about 60 days, and mature plants may grow to 5 feet in height. Unlike the domestic version that is grown for birdseed, wild proso millet seed can remain dormant in the soil for several years. The seed starts to germinate in May and continues germinating until late in the season. Even if the seed germinates relatively late in the season or is injured by herbicides early, it can still grow to produce seed

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before being killed by frost. As the height of the plants increases, they may lodge and develop additional roots wherever stem joints touch the ground.

Wild proso millet can be partially distinguished from fall panicum and similar species by the presence of abundant hairs growing straight out from the stem; fall panicum has a relatively hairless stem. Another panicum called witchgrass (*Panicum capillare*) has hairy stems but does not grow nearly as tall or as vigorously as wild proso millet. The seeds of wild proso millet are much larger than the seeds of witchgrass and fall panicum. Mature seeds of wild proso millet are olive brown to coal black, shiny, and smooth.

The brown to black seed from which a plant sprouts may remain attached to the root system, even to maturity. If you remove the plant carefully from the soil, you can usually find the brown to black seed coat attached in the center of the roots. The seed coat is a good characteristic to check in identifying wild proso millet.

Wild proso millet is a prolific seed producer; often, the ground surrounding an infestation is covered with seed late in the season. Once the seed is mature, it shatters very easily. Seeds are probably transported from field to field on harvesting equipment during the middle to latter part of the summer.

In addition to its hairy stems, wild proso millet has very hairy leaf blades that become 1/3 to 1 inch wide and up to 10 inches long. The seedhead is large and bushy, becoming 4 to 10 inches long; it is shaped like that of fall panicum but is more compact.

Since wild proso millet has only recently moved into the northern border counties of Illinois, specialists at the University of Illinois have not yet conducted extensive research aimed at controlling the weed. The following control suggestions are based primarily on research conducted at the University of Wisconsin and on some observations made by University of Illinois staff members in northern Illinois.

Cultural Control Programs

No single practice, chemical or cultural, has thus far proven entirely effective in controlling wild proso millet in cultivated row crops. Some cultural practices will, however, help reduce the problem significantly over a long period.

Planting of early, broadcast-seeded crops such as alfalfa, small grains, or canning peas has reduced infestations of wild proso millet. Because these crops begin growing early, before wild proso millet germinates, they can gain a competitive advantage over the millet. It is extremely important to maintain a thick and vigorous crop stand since the weed will grow and produce seed at any break in the stand. A disadvantage of growing small grains and peas is that when they are harvested, wild proso millet can then come up and mature rather rapidly. Growing alfalfa seems to be the best long-term cultural control. Once established (with a companion crop or herbicides to control early weeds), alfalfa can maintain a competitive edge over wild proso millet seedlings each year. Mowing regularly prevents production of seed that might develop in spite of the alfalfa competition. You should probably leave infested fields in alfalfa for about five years to reduce significantly the number of millet seed in the soil. Even at the end of that period, there may still be some viable seed.

Chemical Control Programs

In corn, Eradicane (EPTC + safener) is the basis for an effective wild proso millet control program. Because of its short soil persistence, however, Eradicane alone will not provide control through the entire season. Additional herbicide treatments are needed to extend the control period to prevent serious competition from the weed and reduce seed production. Corn should be planted as soon as possible after Eradicane is incorporated to give the crop an early competitive advantage. Corn planted in 30-inch rows has proven to be more competitive than corn planted in 40-inch rows.

A tank mix of Eradicane and Bladex (cyanazine) can suppress wild proso millet. Use 7 1/3 pints per acre of Eradicane, and adjust the Bladex rate according to soil texture and organic matter content. This treatment is better than Eradicane used alone but probably will not prevent an infestation later in the season.

Research findings and grower observations indicate that Eradicane may not perform satisfactorily when applied to fields with a history of Eradicane use. Apparently, soil that is treated with Eradicane can become preconditioned so that subsequent applications of the chemical are broken down more rapidly, although not in all soil types. This preconditioning causes poor weed control primarily by reducing the persistence of the herbicide in the soil. The poor control is most noticeable on weeds such as wild proso millet that germinate over an extended period. The manufacturer of Eradicane is expected to market a new formulation that will include an extender to slow the breakdown of Eradicane in preconditioned soils.

Another option for preconditioned soils is to apply Sutan+ rather than Eradicane. Sutan+ does not control wild proso millet as effectively as Eradicane does but persists longer and may not result in preconditioning of the soil. The longer residual action of Sutan+ should make it at least as effective as Eradicane (without the extender) on the preconditioned soils.

Eradicane tank mixtures can be applied to control the first flush of wild proso millet and thereby set the stage for postemergence treatments. For a postemergence, directed spray of Evik (ametryn), corn should be at least 12 inches tall and weeds less than 6 inches tall. It is extremely important to control the early germinating weeds with Eradicane or Sutan+ to help establish this height differential. Spraying Evik directly on corn can result in crop injury.

Perhaps the most effective, labeled control program to date for controlling wild proso millet in corn is the preplant incorporated treatment of Eradicane alone, followed at the corn spike stage by a tank-mix of Prowl (pendimethalin) plus Bladex 80W. Apply at least 4 3/4 pints of Eradicane per acre and use the maximum allowable rates of Prowl and Bladex for the soil texture and organic matter. Timing of this treatment is critical. Apply it when wild proso millet is no more than 1 inch tall. Since Bladex should not be applied to corn more than once during the growing season, the Prowl/Bladex 80W treatment cannot follow any previous Bladex applications, such as Eradicane/Bladex incorporated. Corn yields and wild proso millet control have generally been improved by use of the Prowl/Bladex tank mix at the spike stage rather than the tank-mix of Bladex with Eradicane. Cultivation can help considerably in both corn and soybeans to assure maximum control of millet.

In soybeans, control of wild proso millet has been difficult. Broadcast or narrow-row planting of soybeans has not been effective because of the relatively late planting dates. By the time soybeans are planted, wild proso millet has already germinated and gained the competitive advantage since it grows so rapidly at that time of the season. Also, the need for cultivation has dictated that soybeans be planted in rows. A dinitroaniline herbicide such as Treflan (trifluralin) appears to be most effective in controlling wild proso millet but only when applied at maximum labeled rates and incorporated uniformly in the top 2 to 3 inches of soil. Amiben (chloramben) as an overlay application has further suppressed the weed when used after a dinitroaniline herbicide.

Some of the new postemergence herbicides for controlling grass weeds in soybeans appear very promising for control of wild proso millet. These herbicides should help reduce the weed problem significantly in soybeans. However, these herbicides should not be relied upon completely. One application will only control the weeds that have emerged. Seed may germinate later and grow to maturity.

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1983 HERBICIDES FOR COMMERCIAL FRUIT CROPS IN ILLINOIS

D.B. Meador, C.C. Doll, and J.W. Courter

The suggestions in this publication comply with the regulations of the U.S. Department of Agriculture and the Environmental Protection Agency in effect at the time this publication was assembled. Since such regulations are subject to change, consult the most recent product label for use restrictions. *Do not use any herbicide unless the label states that it may be used on the crop to be treated.*

When mixtures of chemicals are applied, the user will assume the responsibility for freedom of residues if such applications are not labeled by the EPA as a mixture.

This guide is provided for your information. The University of Illinois and its agents assume no responsibility for results from using herbicides, whether or not they are used according to suggestions, recommendations, or directions of the manufacturer or any governmental agency.

CAUTION

Rates are in the amounts of *product* rather than in amounts of *active ingredients.*

Rates are for full coverage per acre. For spot or band treatments reduce rates in proportion to the area actually treated.

All rates are for silt and/or clay loam soils. Some residual herbicides SHOULD NOT be used on sandy soils. Others can be used on sandy soils at reduced rates. See label.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
APPLES	Sinbar 80W or Princep 80W or Karmex 80W or Surflan 75W or Devrinol 50W	2 to 4 lb. 2-1/2 to 4 lb. 2 to 4 lb. 2-1/2 to 5 lb. 8 lb.	These are preemergence herbicides. They may be used in conjunction with a postemergence herbicide. Apply in the spring before weeds emerge. Do not use on sandy soil. Surflan and Devrinol may be applied to newly planted trees after the soil settles and to bearing and nonbearing trees. Do not use Sinbar on trees established less than 3 years, or Princep or Karmex on trees established less than 1 year. Do not use Karmex on full-dwarf trees. Half rate of two of these materials is sometimes more effective than a full rate of one material. Devrinol must be incorporated within 24 hours by 1/2 inch of rain or irrigation or by shallow cultivation.
	Paraquat CL	1 to 2 qt.	A postemergence herbicide. Use lower rate on young, tender weeds and higher rate on older weeds. Use 8 oz. of nonionic surfactant per 100 gal. of spray to increase effectiveness. Wet foliage! Keep off tree foliage and tender bark. May be used in conjunction with a residual herbicide. Paraquat kills the tops but frequently does not kill the roots.
	2,4-D amine, oil-soluble amine, and acid forms Dacamine 4D and others	see remarks	Use 2 quarts of 4D amine or oil-soluble amine or 3EC acid form plus 2 oz. of surfactant per 100 gal. of water. Spot treat in May, June, July, and August to control bindweed, climbing milkweed, and other broad-leaved weeds. Spray before vines climb into trees. Keep spray drift off apple foliage. May be used as a broadcast treatment in late fall to kill dandelions.
	Ammate X-NI-95W	see remarks	For poison ivy use 60 lb. of Ammate X-NI plus 1 qt. of Surfactant WK per 100 gal. of water. Spot treat in May, June, and July, wetting the ivy foliage. Keep off apple foliage.
	Casoron 4G	150 lb.	This material is both a postemergence herbicide and a residual herbicide. Its action is good in cool weather but dissipates after about 2 months of warm weather. Effective against quackgrass when applied in late fall. Use granular form. Apply any time from fall to early spring. Can be applied on young trees 30 days after planting.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
APPLES (Continued)	Roundup 4EC	1-1/2 to 5 qt.	Roundup is a systemic-type postemergence herbicide to be used in a manner similar to Paraquat. Use sufficient water to wet grass and weed foliage. The rate depends on the weed species. Keep off apple foliage and green-colored bark tissue. It is more effective than Paraquat against perennials. Do not apply within 14 days of harvest.
PEARS	Same as apples, EXCEPT that Sinbar is not registered for pears.		
PEACHES	Princep 80W, or Sinbar 80W, or Karmex 80W, or Devrinol 50W, or Surflan 75W	2-1/2 to 5 lb. 2 to 4 lb. 2 to 4 lb. 8 lb. 2-1/2 to 5 lb.	See remarks under apples. Do not apply Princep on trees established less than 1 year, or Sinbar or Karmex on trees established less than 3 years. Surflan and Devrinol may be used on newly planted trees after the ground settles and on bearing and nonbearing trees.
	Paraquat CL	1 to 2 qt.	See remarks under apples.
	Casoron 4G	150 lb.	See remarks under apples.
CHERRIES AND PLUMS	Princep 80W, or Devrinol 50W, or Surflan 75W	2-1/2 to 5 lb. 8 lb. 2-1/2 to 5 lb.	See remarks under apples. Restrictions are the same as for peaches for Princep, Devrinol, and Surflan.
	Paraquat CL	1 to 2 qt.	See remarks under apples.
	Roundup 4EC	1-1/2 to 5 qt.	Use only on cherries, not on plums. Do not allow spray drift to contact foliage, fruit, green bark or suckers, or the bark of trees established less than 2 years. See remarks under apples.
BLACKBERRIES AND RASPBERRIES	Princep 80W or Princep 4G or Sinbar 80W	2-1/2 to 5 lb. 50 to 100 lb. 1 to 2 lb.	For plantings at least 1 year old. Apply in early spring before weeds emerge and before canes leaf out. On mowed-off Heritage, apply before new shoots emerge. Apply to soil surface at base of plants in a band 30 to 42 inches wide along each side of the row. If winter weeds are a problem in established plantings, use half dosage in late fall and again in early spring. Treated area should not be disturbed or have untreated soil piled over it by cultivating equipment.
	Surflan 75W	2-1/2 to 5 lb.	May be applied to new plantings after the ground settles and to established plantings in the spring before weeds emerge.
	Casoron 4G	100 lb.	Use 4-percent granules. Apply any time from late fall to early spring to kill existing grass and weeds and to reduce growth of young weeds into early summer. Can be applied on new plantings 30 days after planting.
	Enide 50W 90W	8 to 12 lb. 4.4 to 6.6 lb.	Apply as a band application on new plantings of raspberries and blackberries. May be applied in the spring on established raspberries. Do not apply on raspberries within 60 days of harvest or on blackberries within 12 months of harvest.
	Dow General Weed Killer		See remarks under blueberries.
	Paraquat CL	1 to 2 qt.	Apply in spring before emergence of new canes or shoots.
BLUEBERRIES	Princep 80W or Princep 4G or Sinbar 80W	2-1/2 to 5 lb. 50 to 100 lb. 2 to 4 lb.	See remarks under blackberries and raspberries. Apply in early spring to plantings established at least 1 year.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
BLUEBERRIES (Continued)	Casoron 4G	100 lb.	See remarks under blackberries and raspberries.
	Dow General Weed Killer		Use 2 to 3 pints in 10 to 20 gallons of No. 2 diesel fuel made up to 100 gallons with water. Wet weed foliage in the fall after harvest or in the spring before bloom. Use directed spray and do not treat young shoots that one does not wish to kill. See label for mixing instructions.
	Paraquat CL	1 to 2 qt.	See remarks under blackberries and raspberries.
GRAPES	Karmex 80W or Princep 80W	2 to 6 lb. 2-1/2 to 6 lb.	Use in vineyards established at least 3 years. Apply in early spring to soil under trellis in a band 30 inches wide.
	Devrinol 50W or Surflan 75W	8 lb. 2-1/2 to 5 lb.	May be applied to newly planted vines after the soil settles and to nonbearing and bearing vines. Devrinol must be incorporated within 24 hours by 1/2 inch of rain or irrigation or by shallow cultivation.
	Paraquat CL	1 to 2 qt.	Apply as a postemergent spray when annual grasses and weeds become a problem. Keep spray off foliage. Use the surfactant suggested by the manufacturer.
	Casoron 4G	150 lb.	Use 4-percent granules. Apply from late fall to early spring to kill established weeds and grass. Residual effect to kill germinating weeds and grass will last until warm weather.
	Roundup 4EC	1 to 5 qt.	Use as a directed spray in vineyards established at least 3 years or for site preparation prior to planting for control of emerged annual and perennial weeds. Keep spray off green foliage, green bark, and suckers.
STRAWBERRIES (New plantings)	Dacthal 75W	12 lb.	Preemergence action. May be applied immediately after transplanting or during the growing season to weed-free soil. Should be incorporated into the top 1/2 inch of soil with irrigation or rainfall. Will not control ragweed, smartweed, or morning glory. Effective weed control generally lasts 4 to 8 weeks. May be repeated. Cultivation reduces effectiveness.
	Enide 50W 90W	12 lb. 6.6 lb.	Preemergence action. During the first growing season may be applied anytime after the plants become established and the soil is free of weeds. Incorporate in the soil with rainfall or irrigation. May be applied in late fall or early spring to give control through harvest. Do not apply within 60 days before harvest. No more than two applications per year. Cultivation reduces effectiveness.
	Norex 50 W or Tenoran 50W	8 lb. 8 lb.	Postemergence action against young weeds plus some preemergence action. Delay application on new plantings until strawberry plants become established. Not effective on grasses, but will kill many broad-leaved weeds that are less than 1 inch high. Irrigate as soon as possible after application if soil is dry. Do not apply when temperature is above 90° F., because injury to foliage may occur. Cultivation will destroy effectiveness. No more than two applications per year. Follow special mixing instructions. Do not apply within 60 days before harvest.
	Devrinol 50W	4 to 8 lb.	Application of Devrinol should be delayed until the desired number of daughter plants has become established. Devrinol may retard the rooting of daughter plants. Must be incorporated into the soil with at least 1/2 inch of irrigation within 24 hours after application.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
STRAWBERRIES (Established plantings)	Dacthal 75W	12 lb.	Preemergence action. See remarks for new plantings. Do not apply when blossoms or fruit are present.
	Enide 50W 90W	8 to 12 lb. 4.4 to 6.6 lb.	Preemergence action. Apply after renovation and/or in late fall or early spring. For best results, irrigate immediately or apply to moist soil. Apply before weeds germinate. Effective against fall- and spring-germinating grasses and some broad-leaved weeds. A late August application controls winter annuals. A late fall application just before mulching should control spring-germinating grasses and weeds through harvest. Do not apply within 60 days before harvest. No more than two applications per year.
	2,4-D amine Formula 40	1 to 1-1/2 qt.	Postemergence action. To control many broad-leaved weeds in established plantings apply in 25 to 50 gallons of water per acre in late fall or early spring when strawberries are dormant. 2,4-D may also be applied at renovation time.
	Norex 50W or Tenoran 50W	8 lb. 8 lb.	May be applied at renovation time. It will kill some existing weeds and also give some preemergence protection. It may also be applied in early spring to kill existing chickweed. Do not apply within 60 days before harvest. Do not make more than two applications per year.
	Sinbar	1/4 to 1/2 lb.	Apply no more than 1 pound per year. May be applied at renovation if all leaves are removed before spraying. Or apply to fully dormant plants from late fall to late winter. May apply 1/2 pound at renovation and again in late fall. Application rate must be accurate and must be adjusted to soil type and soil organic matter content. See label. Excess rates may cause serious injury. Growers using Sinbar for the first time should limit application to a small part of their plantings.
	Devrinol 50W	4 to 8 lb.	Preemergence action. May be applied anytime except from bloom to harvest or when the ground is frozen. It must be incorporated with at least 1/2 inch of irrigation or rainfall within 24 hours after application.

CAUTIONS

If you are applying herbicides for the first time or are trying a new herbicide, learn on a small area.

Avoid spray drifts. Use low pressure (30 to 60 pounds per square inch) with nozzles close to the ground. Spray when wind velocity is low.

Calibrate equipment to apply the correct amount of material per acre. Excessive amounts may cause damage to fruit plants. Lesser amounts may not give control. Uniform application is essential.

Clean sprayers after applying herbicides. Use detergent and water (2 cups in 25 gallons) or ammonia and water (1 quart in 25 gallons) to clean out wettable-powder sprays. Emulsifiable liquids should first be washed out with kerosene, then with detergent and water or ammonia and water. Do not allow drain solutions to run into streams or other water sources.

For herbicide suggestions in home fruit plantings, see Circular 1144, "Controlling Weeds in Home Fruit Plantings."

Weed Management Guide 1983

FOR COMMERCIAL VEGETABLE GROWERS

Restricted-use herbicides are identified with an asterisk(*).
You must be certified as a pesticide applicator to use restricted-use pesticides.
See your county Extension adviser in agriculture for information.

WEED GROWTH reduces the income of vegetable growers in the United States by millions of dollars annually as a result of lower yields, poorer quality, and added labor in harvesting and processing.

This guide should be used together with the grower's knowledge of soil types and the crop and weed history of the area to be treated. Whether to use herbicides or other means of weed control depends in part on the severity of past weed infestations. In some instances, mechanical control may be sufficient. If so, shave off weeds with a sharp hoe or cultivator while gently breaking up the crust. Deep tillage causes severe injury to many shallow-rooted plants and helps place a fresh supply of weed seeds in position to germinate. Keeping equipment sharp and in good condition will help reduce injury to desirable plants. Hoe carefully around your plants, and hand pull weeds close to the plants.

For warm season crops such as fresh market tomatoes, peppers, eggplant, okra, cucumbers, and melon, black polyethylene mulch will control annual weeds, conserve moisture, and increase the soil temperature in early spring. The higher temperature increases early season growth. Natural mulch materials may require considerable hand labor for application. Most organic materials are bulky and must be hauled to the place of use. This is a problem for large commercial plantings. Organic mulches tend to reduce soil temperature.

Herbicide application may be needed in addition to mechanical control. Several herbicides may be suggested for some crops. These herbicides have shown good control with no injury to the vegetables under test conditions. Not all herbicides cleared for use on a species are necessarily listed. Where the choice of more than one herbicide is suggested, the decision rests with the grower and is based on his knowledge of past weed infestations, crop rotations, and material costs. Where one herbicide will not control the weeds present, a combination of herbicides may be suggested. When using a herbicide for the first time, it is advisable to use a small-scale trial.

These suggestions for weed control in vegetables are based on research at the Illinois Agricultural Experiment Station, the U.S. Department of Agriculture, and other research institutions. The University of Illinois and its agents assume no responsibility for results from the use of herbicides, whether or not they were used in accordance with suggestions, recommendations, or directions of the manufacturer or any governmental agency.

Reading the label of the herbicide container is the most profitable time you spend in weed control. Use of the material and methods of application and use depend on registration of the herbicide by federal and state Environmental Protection Agencies (EPA). Do not use any herbicide *unless the label states that it is cleared for the use on the crop to be treated.*

Herbicides are being classified for *general use* or *restricted use* by the U.S. Environmental Protection Agency. A person wishing to use a herbicide classified for restricted use must be certified as a private or commercial pesticide applicator by the Illinois Department of Agriculture. Contact your county Extension adviser in agriculture for details about this program.

Only a few herbicides have been classified at this time. More may be classified later.

When applying mixtures of chemicals, the *user* assumes responsibility for freedom from residues if the mixture is not labeled by the EPA.

Suggestions sometimes change during the growing season, based on EPA clearances that were made after this circular was issued. This publication, printed once a year, is subject to change without notification.

Watch for notice of changes in the EPA registration of herbicides (as released by the EPA) in the *Illinois Vegetable Farmer's Letter* and the *Insect, Weed, and Plant Disease Survey Bulletin.* Subscription forms for the latter are available from the Agricultural Newsletter Service, 116 Mumford Hall, 1301 West Gregory Drive, Urbana, Illinois 61801, or your county Extension Office. You can obtain the *Vegetable Farmer's Letter* from Vegetable Crops Extension, University of Illinois, 1103 West Dorner Drive, Urbana, Illinois 61801.

CIRCULAR 907

Prepared by H. J. Hopen, Department of Horticulture

For Application During the Growing Season (1983 Only)

Crop	*Treatment*	*Active ingredient per acre actually covered*[a]	*Weeds controlled*	*Timing of application (based on crop stage)*	*Remarks, cautions, limitations*
Asparagus (seedlings)	Amiben	3 lb.	Annuals	Immediately after seeding	Irrigation or rainfall after treatment will give maximum control.
Asparagus (established plantings)[b, c]	dalapon	5-10 lb.	Perennial grass	End of harvest season following disking	Apply when grass weeds are 3 to 4 in. tall. Direct spray under fern growth. Use surfactant as directed on label.
	diuron	1-4 lb.	Annuals	In spring, after harvest, or both	Apply after disking. Do not exceed 6 lb. per growing season; use a lighter rate on sandy soil. With diuron and Princep, a spring application may be sufficient after the first year.
	Princep	3-4 lb.	Annuals	In spring, after harvest, or both	Apply after disking. Do not treat during the last year in asparagus because of residue.
	Sinbar	1.2-2.4 lb.	Annuals	In spring, after harvest, or both	Use lower rates on coarse soils. Do not apply more than 2.4 lb. per acre per year. Do not use on soils with less than 1 percent organic matter. Do not plant to any other crop for two years after application.
	metribuzin	1-2 lb.	Primarily broad-leaf weeds	Early spring before the spears emerge or after harvest	Apply after disking. Do not apply within 14 days of harvest. Can help control broadleaf weeds when used with dalapon, diuron, or Princep. Do not apply more than 2 lb./acre per growing season.
	Preemergence				
Beans, dry, lima and snap[d]	Treflan	0.5-0.75 lb.	Annuals[e] (primarily grasses)	Preplant soil application, incorporate with soil immediately	Plant crop immediately, or within 3 weeks after application. Can use up to 1 lb. per acre on dry beans.
	Basalin	0.75-1.5 lb.	Annuals (primarily grasses)	Preplant soil application, incorporate with soil immediately	
	dinoseb	6-7.5 lb.	Annuals	Can be used between planting and crop emergence	Do not use on light, sandy soil. Some stand reduction may result from use. See label for precautions.
	Postemergence				
	Basagran	0.75-1 lb.	Annual broad-leaf weeds, Canada thistle, nutsedge	When weeds are small and are actively growing; after the first trifoliate leaf appears on beans	Can provide good, broad-spectrum control when combined with a grass-active herbicide. Do not mix with other pesticides. See Basagran entry under corn, postemergence for Canada thistle and nutgrass control.
Beans, snap	Eptam	3 lb.	Annual grasses and nutgrass[f]	Preplant soil application, incorporate with soil immediately	
	Eptam + Treflan	2-3 lb. 0.5-0.75 lb.		Preplant soil application, incorporate with soil immediately	TRIAL USE IN 1983. Research results have shown this combination to control a broader spectrum of weeds than either herbicide alone.
	Dacthal	6-10 lb.	Annuals[g] (primarily grasses)	Immediately after seeding	Do not feed treated plant parts to livestock.
Beans, lima and dry	Amiben	2-3 lb.	Broad spectrum of annual weeds	Immediately after seeding, or preplant-incorporated for lima beans	Field may be rotary-hoed without destroying herbicide action.
	Dual	1.5-3 lb	Annuals	Preplant soil application, incorporate with soil, or preemergence	
	Lasso	2-3 lb.	Annuals	Lima beans: preplant soil application, incorporate into upper 1 to 2 inches. Dry beans: preplant soil application, incorporate into upper 1 to 2 inches, or preemergence	
Beans, dry	Eptam + Treflan	2-3 lb. 0.5-0.75 lb.		Preplant soil application, incorporate with soil immediately	TRIAL USE IN 1983. Research results have shown this combination to control a broader spectrum of weeds than either herbicide alone.
Beets, garden[d]	Pyramin	4 lb.	Annuals (primarily broadleaved)	Preemergence or after beets emerge and before weeds have two true leaves	Rainfall or irrigation needed to activate. Where grasses are a severe problem, use 4 lb. of Pyramin plus 4 lb. of Ro-Neet.
	Ro-Neet	4 lb.	Annual grasses	Preplant soil application, incorporate with soil immediately	Use a combination treatment with Pyramin to broaden control spectrum.
	Direct-seeded or transplanted				
Broccoli[d] Brussels sprouts[d]	Treflan	0.5-0.75 lb.	Annuals[e] (primarily grasses)	Preplant soil application, incorporate with soil immediately	Stunting or growth reduction may occur at recommended rates under growth stress conditions. Can use up to 1 lb. per acre on transplants.
Cabbage[d] Cauliflower[d]	Dacthal	6-10 lb.	Annuals[g] (primarily grasses)	Immediately after seeding. Can also be incorporated preplant	
	Preemergence				
Carrots[d]	Treflan	0.5-1 lb.	Annuals[e] (primarily grasses)	Preplant soil application, incorporate with soil immediately	Seed after application to 3 weeks later.

Carrots continued on the next page.

All notes are at the end of this table.

For Application During the Growing Season (continued)

Crop	*Treatment*	*Active ingredient per acre actually covered*[a]	*Weeds controlled*	*Timing of application (based on crop stage)*	*Remarks, cautions, limitations*
	Postemergence				
Carrots (continued)[d]	Lorox	0.75-1.5 lb.	Annuals	Postemergence on carrots only after the crop is 3 in. tall; grasses, less than 2 in.; broadleaves, less than 6 in.	Do not feed treated foliage to livestock or replant treated area for 4 months. More than one application may be made, but do not exceed a total of 2 lb. per acre. Do not use over 40 PSI. Use no surfactants when temperatures exceed 80°F., or crop injury may result.
	Stoddard Solvent	60-80 gal.	Annuals	After two true leaves have appeared (do not apply to carrots or parsnips after they are ¼ in. in diameter, since an oily taste may result)	Most effective when sprayed on cloudy days or during high humidity, and when weeds are not more than 2 inches high. May not control ragweed. Do not apply within 40 days of harvest. Can be used on celery, dill, parsnips, and parsley.
	Preemergence				
Corn, pop[d]	atrazine	2-3 lb.	(See sweet corn)	(See sweet corn)	See sweet corn, *except the section on preemergence combinations.*
	Bladex	(See remarks)	Annuals	Preemergence only	Some pop corn varieties are sensitive to the application rate. (See remarks on Bladex under sweet corn.)
	Dual	1.5-3 lb.	Annuals	Preplant soil application, incorporate with soil, or preemergence	
	Eradicane, Eradicane Extra	4-6 lb.	Difficult-to-control weeds	Preplant soil application, incorporate with soil	See sweet corn.
	Lasso	2-3 lb.	Annuals	Preemergence	See sweet corn.
	Princep	2-3 lb.	Annuals	Preemergence	Plant only crops so specified on the label the following year. Do not graze treated areas.
	Sutan+	3-4 lb.	Primarily annual grasses	Preplant soil application, incorporate with soil	See sweet corn.
	Postemergence				
	2,4-D	0.5 lb.	Broadleaved weeds	Postemergence	Apply when corn is 3 to 10 in. tall.
	Preemergence				
Corn, sweet[c,d]	atrazine	2-3 lb.	Annuals, annual and perennial grasses[b]	Preemergence, apply no later than 3 weeks after seeding. Shallow cultivation may improve weed control during dry weather.	Grow corn a second year without atrazine treatment. This chemical has a high soil residue. Do not plant other vegetable crops on a sprayed area until a second year of corn has been grown. Use atrazine where quackgrass is a problem. Residue hazard decreased when banded or in combination with Lasso, propachlor, or Sutan.
	Bladex	(See remarks)	Annuals	Preemergence only	Some sweet corn varieties are sensitive to the application rate. Has been shown to have less soil residue than atrazine. See label for rates and precautions. Do not use postemergence, or on sandy or loamy-sandy soils (under 1 percent organic matter). Can be combined with other herbicides to reduce the rate being used. NOTE: The Shell Chemical Co. has a bulletin on using Bladex on pop and sweet corn.
	Dual	1.5-3 lb.	Annuals	Preplant soil application, incorporate with soil, or preemergence	
	Eradicane, Eradicane Extra	4-6 lb. 4 lb.	Difficult-to-control weeds	Preplant soil application, incorporate with soil	Use to control weeds that are difficult to control with other herbicides, such as wild cane, nutsedge, quackgrass, wild Proso millet, and seedling Johnsongrass. Eradicane Extra contains an "extender" which may lengthen the period of control in fields where Eradicane control has been shortened after several years of continuous use.
	Lasso	2-3 lb.	Annuals	Preemergence	Preplant incorporation may aid control of nutgrass.
	propachlor	4-5 lb.	Annuals	Preemergence	Do *not* use on sandy soils. Is an excellent herbicide on soils with a high organic-matter content.
	Sutan+	3-4 lb.	Primarily annual grasses	Preplant soil application, incorporate with soil	Especially useful on sandy soil and where nutgrass is a problem.
	Combinations				
	Dual, Eradicane, Eradicane Extra, Lasso, propachlor, and Sutan+ may be combined with atrazine or Bladex to broaden the spectrum of weed control and reduce residue and carryover. See labels of herbicides for rates and application methods.				
	Postemergence				
	2,4-D (amine)	0.5 lb.	Broadleaved weeds	Postemergence	Preferably, apply before corn is 6 in. tall. If corn is over 12 in., reduce the rate to ¼ lb.
	atrazine	2 lb.	Annuals, annual and perennial grasses[b]	Directed spray 3 weeks after emergence	Can be combined with crop oils for postemergence application as emergency measure. This may increase residue the following year; preemergence use preferred. Do not graze or feed treated foliage for 21 days after treatment.
	Basagran	0.75-1 lb.	Broadleaved annual weeds, Canada thistle, and nutsedge	Early postemergence when the weeds are small and actively growing. Delay will result in less control.	For Canada thistle and nutsedge, split applications are preferred. Make the first one when the plants are 6 to 8 in. tall; for nutsedge, 7 to 10 days later; for Canada thistle, 10 to 14 days later (or use one application plus cultivation). Do not mix with other pesticides.

All notes are at the end of this table.

For Application During the Growing Season (continued)

Crop	Treatment	Active ingredient per acre actually covered[a]	Weeds controlled	Timing of application (based on crop stage)	Remarks, cautions, limitations
Cucumbers Muskmelons[e] Watermelons[e]	Alanap L	3-5 lb.	Annuals[f]	Immediately after seeding or transplanting	Do not use on cold soil. Rainfall or irrigation after treatment gives maximum control.
		3-3.5 lb.		After transplanting or vining	Keep away from foliage. Apply to soil after the weeds have been removed.
	Prefar	4-6 lb.	Annuals (primarily grasses)	Preplant soil application, incorporate with soil immediately	Is primarily a grasskiller. Consult label for sensitive crops within 18 months after application. Can be used in rotation with tomatoes, broccoli, cauliflower, lettuce, carrots, onions, and summer squash within 18 months. Soybeans can be planted 12 months after application.
	Prefar plus Alanap L	4 lb. +2-3 lb.	Grasses and broadleaved weeds	Preplant light incorporation	Has value for broad-spectrum weed control. Consult label for sensitive crops within 18 months after Prefar application. Has EPA approval as a tank mixture.
	Where earliness is desired, black polyethylene mulch can be used as an alternative to herbicides. It will control annual weeds, conserve moisture, and increase the soil temperature in early spring.				
Eggplant	Dacthal	6-10 lb.	Annuals[g] (primarily grasses)	After plants are established, 4-6 weeks after transplanting	Cultivate and weed prior to application. Can be applied to plants as part of a uniform soil application.
	Devrinol	1-2 lb.	Annuals	Preplant soil incorporation	For use in transplanted eggplant.
	Where earliness is desired, black polyethylene mulch can be used as an alternative to herbicides. It will control annual weeds, conserve moisture, and increase the soil temperature in early spring.				
Greens (for beets, mustard greens, and spinach — see note d)	Dacthal	6-10 lb.	Annuals[g] (primarily grasses)	Immediately after seeding	For use on collards, kale, mustard greens, and turnips.
	Treflan	0.5-0.75 lb.	Annuals[e] (primarily grasses)	Preplant soil application, incorporate with soil immediately	For use on collards, kale, mustard greens, and turnip greens.
	Furloe	1-2 lb.	Primarily broad-leaved annuals	Preemergence	For spinach only. Use lower rates in cool, wet weather.
Horseradish[d]	Dacthal	6-10 lb.	Annuals[g] (primarily grasses)	Immediately after transplanting	
Lettuce[c,d]	Balan	1.5 lb.	Annuals	Preplant soil incorporation Incorporate with soil immediately	Is primarily a grasskiller. Seed after application to 3 weeks later. Do not plant wheat, barley, rye, grass, onions, oats, beets, or spinach for 12 months after application.
	Kerb*	1-2 lb.	Annuals	Preemergence or preplant-incorporated	Do not use when the air temperature exceeds 85° F. Use the lower rates listed on sandy soil. Do not use on peat or muck soils. See label for rotation crops. For best results, rainfall or irrigation is needed 1 to 2 days after application, especially during warm weather.
Okra[d]	Dual	1.5-3 lb.	Annuals	Preplant soil application, incorporate with soil, or preemergence	
	Enide	3-5 lb.	Annuals	At planting	
	Treflan	0.5-1 lb.	Annuals (primarily grasses)	Preplant soil application, incorporate with soil immediately	
	Where earliness is desired, black polyethylene mulch can be used as an alternative to herbicides. It will control annual weeds, conserve moisture, and increase the soil temperature in early spring.				
	Preemergence				
Onions[b]	Dacthal	6-10 lb.	Annuals[g] (primarily grasses)	Immediately after seeding or transplanting	May not kill smartweed or common ragweed. Can be used on seeds, sets, or seedlings. Use only on mineral soils. Use lower rates on sandy soils. A double application of Dacthal can be used at seeding, layby, or both.
	Randox	4-6 lb.	Annuals[i] (primarily grasses)	Just before onions emerge	Use on muck soils. Heavy rainfall may reduce stand. Very effective on purslane and pigweed.
	Postemergence				
	Furloe	3-6 lb.	Broadleaved weeds (especially smartweed)	On seeded onions: loop stage or after 3- to 4-leaf stage	In later sprays, direct at base of onion plant. If applied more than once, do not exceed 6 lb. per acre for the season. *Use lower rates in cool, wet weather.* Use no later than 30 days before harvest. Do not use on sandy soils.
	Brominal	0.25-0.38 lb.	Broadleaved weeds	When onions have 2 to 5 true leaves	TRIAL USE IN 1983. Use 50 to 70 gallons of water per acre. Apply when onion foliage is dry for greatest crop safety. Suggested temperature for spraying is 80° F with low humidity.
	Preemergence				
Peas[d]	propachlor	4-4.9 lb.	Annuals	Preemergence	Do *not* use on sandy soil.
	Treflan	0.5-0.75 lb.	Annuals[e]	Preplant soil incorporation, incorporate with soil immediately	Seed after application to 3 weeks later. Some reduction of growth and stand reduction possible under stress. May suppress some root rot.

Peas continued on the next page.

All notes are at the end of this table.

For Application During the Growing Season (continued)

Crop	Treatment	Active ingredient per acre actually covered[a]	Weeds controlled	Timing of application (based on crop stage)	Remarks, cautions, limitations
Peas (continued)[d]	Treflan + Surflan	0.5 lb. + 0.5 lb.	Annuals	Preplant soil application, incorporate with soil immediately	Do not use on soils of less than 1.5 percent organic matter. May suppress Aphanomyces root rot. May broaden weed control more than either herbicide alone. Do not feed forage to livestock. Do not plant any root crop for 12 months after application.
	Basalin	0.75-1.5 lb.	Annuals (primarily grasses)	Preplant soil application, incorporate with soil immediately	
	Dual	1.5-3 lb.	Annuals	Preplant soil application, incorporate with soil, or preemergence	
	Preemergence or Postemergence				
	dinoseb	0.3-9 lb.	Annuals (primarily broad-leaved weeds)	Preemergence or postemergence	Preemergence, use 6 to 9 lb.; postemergence, use 0.3 to 1.1 lb. Apply prior to bloom when peas are 2 to 8 in. tall. See label for further precautions. Preemergence use may help suppress root rot.
	Postemergence				
	Basagran	0.75-1 lb.	Annual broad-leaved weeds, Canada thistle, nutsedge	When weeds are small and are actively growing; after peas have 3 pairs of leaves (or 4 nodes)	Can help control Canada thistle. Can provide good, broad-spectrum control when used with a grass-active herbicide. Do not mix with other pesticides. See Basagran entry under corn, postemergence for Canada thistle and nutgrass control.
	MCPB	1 lb.	Broadleaved weeds and Canada thistle	When peas are 3-7 in. tall and no later than 4 nodes prior to pea blossom	May delay maturity 1 to 4 days. Use at least 20 gallons of water per acre. Do not feed vines to livestock. MCPA is more effective on mustard. MCPB or Vacate may be less injurious to peas.
	MCPA (Na salt)	0.25-0.5 lb.			
	Vacate (MCPA amine)	0.115-0.154 lb.			
Potatoes, Irish[c,d]	Dual	1.5-3 lb.	Annuals	Drag-off treatment at emergence	
	Eptam	3-6 lb.	Annual grasses and nutgrass[f]	Drag-off treatment at emergence or preplant soil application; incorporate with soil immediately	Use lower rate on sandy soil.
	Treflan	0.5-1 lb.	Annuals[e] (primarily grasses)	Drag-off treatment at emergence	Use a light incorporation.
	Lorox	0.75-2 lb.	Annuals	Apply prior to potato emergence	Plant tubers at least 2 in. deep. Do not replant treated area to other crops for 4 months after treatment. May injure crop on light, sandy soil. Do not apply over exposed tubers.
	dalapon	7 lb.	Quackgrass	Before plowing in spring; wait 4 days before plowing and planting	Not for fields intended for red-skinned varieties or White Rose. Do not plant potatoes for 4 weeks. Use surfactant as directed on label.
	metribuzin	0.25-0.5 lb.	Annuals (primarily broadleaved)	Postemergence, following a preemergence grass herbicide	Can be used preemergence also. Do not exceed 1 lb. per acre in a season. Do not apply within 60 days of harvest. Do not use on red-skinned or early-maturing white varieties. Do not apply in cool, wet weather.
	Lasso	2.5-3 lb.	Annuals	Apply at drag-off	Do not use on sandy soils. Can be used alone or in combination with Lorox or dinoseb.
Potatoes, sweet[b]	Dacthal	6-10 lb.	Annuals[g] (primarily grasses)	Immediately after planting	
	Amiben	3 lb.	Annuals	Immediately after planting	
	Enide	4-6 lb.	Annuals	Immediately after transplanting	Do not plant nonapproved crops on treated soil during the same season.
Squash Pumpkins	Amiben	3-4 lb.	Annuals	As soon after seeding as possible, or preplant-incorporated	Use on loam soils. Amiben can be applied broadcast or banded over the row in pumpkins.
	Prefar	4-6 lb.	Annuals (primarily grasses)	Preplant soil application, incorporate with soil immediately	Use on sandy soils. Is primarily a grasskiller. Consult label for sensitive crops within 18 months after application. Can be used in rotation only with tomatoes, broccoli, cauliflower, lettuce, carrots, onions, and summer squash within 18 months of application. Soybeans can be planted 12 months after application.
Pumpkins	propachlor	4-5 lb.	Annuals	Preemergence	Do *not* use on sandy soils.
Tomatoes, direct-seeded and transplanted[c]	Enide	4-6 lb.	Annuals	Preemergence	Do not plant other food crops on treated areas for 6 months. If used under dry soil conditions, a shallow (1 in.) incorporation as a preplant treatment may improve weed control. Can also be used on transplanted peppers.
	Devrinol	1-2 lb.	Annuals	Preplant soil incorporated	Also used on direct-seeded and transplanted peppers. Enide + Devrinol is labeled as a tank mixture.

Tomatoes continued on the next page.

All notes are at the end of this table.

For Application During the Growing Season (continued)

Crop	*Treatment*	*Active ingredient per acre actually covered*[a]	*Weeds controlled*	*Timing of application (based on crop stage)*	*Remarks, cautions, limitations*
Tomatoes (continued)[c]	metribuzin	0.25-1 lb. (min.-max.)	Primarily broad-leaf. Should be used with a grass-active herbicide.	Preplant incorporated. Post-emergence, can be broadcast or directed.	Apply with ground equipment to seeded and transplanted tomatoes. Do not use air-blast or other high-pressure spray equipment. Do not use on peppers.
		0.25-0.5 lb.		Preplant incorporated, transplant tomatoes	Alone or in a tank-mix combination with Treflan.
		0.25-0.5 lb.		Broadcast spray, established tomatoes	Single or multiple applications. Minimum of 14 days between treatments. Direct-seeded plants should have 5 or 6 leaves; transplants should show new growth.
		0.5-1 lb.		Directed spray, established tomatoes	Recommended for use in fields with severe weed problems, or for fields with hard-to-control weeds.
		(For min.-max. rates)			Do not apply within 7 days of harvest, or within 3 days following cool, wet, or cloudy weather; otherwise, crop injury may occur. Do not apply to established tomatoes within 24 hours after application of other pesticides. Do not apply more than 1 lb./acre per crop season, or more than 1 lb./acre within a 35-day period. Allow at least 14 days between applications, regardless of the dosage or method used. Do not use hot caps on tomatoes within 7 days before application, or at any time afterward. Do not tank-mix with other pesticides, except Treflan.
Tomatoes and Peppers, transplanted	Amiben	3-4 lb.	Annuals	Wait 3 days after transplanting to apply	Use granular formulation only. Apply to dry foliage in order to avoid leaf burn. Do not use on sandy soils.
	Treflan	0.5-1 lb.	Annuals[e] (primarily grasses)	Preplant soil application, incorporate with soil immediately	Some reduction of growth may be possible under growth stress conditions, or if rates are higher than suggested for the soil type.
	Where earliness is desired, black polyethylene mulch can be used as an alternative to herbicides. It will control annual weeds, conserve moisture, and increase the soil temperature in early spring.				

*** Restricted-use herbicide.**

[a] Based on active ingredients (actual amount of active herbicide in material or acid equivalent). Use lower rate on sandy soil and higher rate on clay and loam soils. When using a band application over the row, adjust amount of material applied to the part of an acre treated. [b] For perennial weed control, applications during and outside the growing season, see the following table. [c] For stale seedbeds, before crop emergence, see the following table. [d] For perennial grass control, applications outside the growing season, see the following table. [e] May not control ragweed and panicum. [f] May not control smartweed. [g] May not control ragweed, smartweed, and velvetleaf. [h] May not control crabgrass. [i] May not control smartweed and velvetleaf.

For Application Outside the Growing Season

	Stale seedbed, before crop emergence				
Asparagus	paraquat*	0.5-1 lb.	All emerged green foliage	Before crop emergence; allow maximum weed emergence prior to treatment	Weeds that emerge after treatment will not be controlled. Crop plants that have emerged at application will be injured. Do not apply within 18 months of harvest. Use with a preemergence or preplant sustained-action weed control system.
Corn, sweet Lettuce Melons Peppers Potatoes Tomatoes	paraquat*	0.5-1 lb.	All emerged green foliage	Before crop emergence	Weeds that emerge after treatment will not be controlled. Crop plants that have emerged at application will be injured. Use with a preemergence or preplant, sustained-action weed control system.
	Perennial weed control, applications during and outside the growing season				
Asparagus	Roundup	2-5 lb.	(See remarks)	Before emergence, or with shielded or directed sprays during fern growth	Use to control milkweed, thistle, field bindweed, quackgrass, or Johnsongrass. Apply to quackgrass when it is 6-8 in. tall in the fall or spring. Apply to Johnsongrass when it is at least 12 in. tall and actively growing. Do not till for the specified time for each species (see label). Does not provide residual weed control. Do not mix, store, or apply Roundup spray solutions in containers or spray tanks made of galvanized or unlined steel (except stainless steel).
	Perennial grass control, applications outside the growing season				
Asparagus Beans, edible Beet greens Beets, red Broccoli Cabbage Cauliflower Corn, sweet and pop Horseradish, as a weed and as a crop Jerusalem artichoke	**Roundup** Kale Lentils Lettuce Mustard greens Okra Onions Peas Potato, Irish and sweet	2-3 lb.	(See remarks) Radishes Spinach	(See remarks)	Use for quackgrass or Johnsongrass control. Apply to quackgrass when 6 to 8 in. tall in fall or spring. Apply to Johnsongrass when at least 12 in. tall and actively growing. Do not till until 3 to 7 days after application. Does not provide residual weed control. Do not mix, store, or apply Roundup spray solutions in galvanized steel or unlined steel containers (except stainless steel). For control of volunteer horseradish, apply 3 to 4 lb. in mid-September. Field should have been disced 4 to 6 weeks prior to application. For this control practice, use spray coverage only.

*** Restricted-use herbicide.**

NOTE: In the suggestions in this publication, trade names of herbicides are usually used. The list below shows trade names and their corresponding common names. **Restricted-use herbicides are identified with an asterisk(*).**

Common name	Trade name
alachlor	Lasso
atrazine	AAtrex and Atrazine
benefin	Balan
bensulide	Prefar
bentazon	Basagran
bromoxynil	Brominal
butylate+safener	Sutan+
CDAA	Randox
chloramben	Amiben
chlorpropham	Furloe
cyanazine	Bladex
cycloate	Ro-Neet
dalapon	Dowpon
DCPA	Dacthal
dinoseb	Premerge-3, Sinox, Dinoseb
diphenamid	Enide
diuron	Karmex and others
EPTC	Eptam
EPTC+safener	Eradicane
EPTC + safener + extender	Eradicane Extra
fluchloralin	Basalin
glyphosate	Roundup, Kleen Up
linuron	Lorox
MCPA, MCPB	Vacate, numerous
metolachlor	Dual
metribuzin	Lexone, Sencor
napropamide	Devrinol
naptalam	Alanap L
paraquat*	Paraquat,* Gramoxone*
pronamide*	Kerb*
propachlor	Ramrod, Propachlor
pyrazon	Pyramin
oryzalin	Surflan
simazine	Princep
terbacil	Sinbar
trifluralin	Treflan
Petroleum solvent	Stoddard Solvent
2,4-D (amine)	(numerous)

Storing Pesticides and Containers

Keep pesticides and containers in a separate building, room, or enclosure used only for this purpose. Such building or rooms should be dry, ventilated, and locked. Fence outside storage areas to protect children and animals and to discourage pilferage. CAUTION: Do not store weedkillers, herbicides, or defoliants in the same room with insecticides. Chlorate salts can create a fire or explosion hazard. Remove only the pesticides needed for one day's operation and return empty containers — and any unused pesticide — to the storage area each day.

Disposing of Pesticides and Containers

Surplus pesticides. To dispose of surplus pesticide mixtures, try to find other areas with the same pest problem and use up any extra tank mix or rinse water on these areas. Do not drain surplus pesticides in any location where they can contaminate wells, streams, rivers, lakes, or ponds.

Operators of landfills meeting environmental safety standards can obtain supplemental permits to handle toxic waste materials, including pesticides. To dispose of large quantities of surplus pesticides, contact the Illinois EPA Division of Land Pollution Control to locate the nearest landfill with a supplemental permit for toxic waste or to obtain specific instructions about disposal.

Pesticide containers. All empty pesticide containers, regardless of their type, should be rinsed three times before disposal. Rinse water should be dumped in the tank. Triple-rinsed containers should be punctured or broken to facilitate drainage and to prevent reuse for any purpose. They should then be hauled to a sanitary landfill for disposal. Small quantities of containers may be buried singly in open fields, with due regard for the protection of surface and subsurface water.

Illinois regulations permit the burning of combustible containers provided that they are burned on the premises where they were used, that they are burned more than 1,000 feet from residential areas, that the burning will not cause undue visibility or environmental hazards, and that no reasonable alternative disposal method is available.

Do not breathe smoke from burning pesticide containers, and do not burn containers that have weedkillers such as 2,4-D or similar herbicides. When these change to a gas, the vapors may damage nearby crops and shrubbery. Pesticides containing chlorates may explode when heated and therefore should not be burned.

Growers with Several Crops in a Small Area

Growers with several crops in a small area should be especially careful when applying herbicides. The tendency is to apply more if the quantity measured out "looks" as if it is not enough. A low-percentage granular formulation is suggested for small areas. *Check rates and application techniques on the container label very carefully. Applications must be accurate and uniform. Excessive amounts may cause injury to present or subsequent crops.*

Ideally, a specific herbicide should be fitted to a specific crop species. When growing several different crops in a small area, however, it is often impractical and expensive to use all the appropriate herbicides. Following are two herbicides that can be used on a wide range of vegetables.

Dacthal. Dacthal is cleared on a large number of vegetables. As listed in this circular, it may not always be the herbicide of preference. It can be used on broccoli, brussels sprouts, cauliflower, cabbage, snap beans, mung beans, Southern peas, soybeans, seeded melons, cucumbers, squash, collards, kale, mustard greens, turnips (root and greens), garlic, horseradish, onions, potatoes (Irish), sweet potatoes and yams, tomatoes, eggplant, peppers, and strawberries. *Do not use on beets or Swiss chard.*

Dacthal is a preemergence herbicide that must be applied to weed-free soil. It controls very small weed seedlings soon after the weed seeds germinate. It is most effective if rainfall occurs or if the soil is irrigated within 2 to 3 days after application.

A one-time application to all species is not always possible because some plants are susceptible to injury in early-growth stages. It is preferable to use Dacthal at seeding or transplanting time if the species is adapted to it. When this is not possible, the weeds should be removed and Dacthal applied to prevent further weed development. Consult the label for the appropriate application time.

Dacthal is effective in controlling annual grasses that are a problem in the spring. Broadleaf weeds that escape control should be mechanically removed.

Treflan. Treflan is widely available because it is used in soybean culture in Illinois. It can be purchased as a liquid with 4 pounds of active ingredient per gallon for large garden areas or as a low-percentage granular formulation for smaller areas. The amount of Treflan to use correlates very closely with the type of soil. The appropriate amounts are shown on the container label.

Treflan can be used for weed control in beans (green, lima, and dry), broccoli, brussels sprouts, cabbage, cauliflower, carrots, kale, mustard greens, okra, peas, peppers, tomatoes, and turnip greens. *Treflan may injure sweet corn.*

Treflan must be mixed with or watered into the soil to prevent loss of the chemical from the soil surface. A rototiller, disc, or similar implement should be used to mix Treflan with the soil to a 3- to 4-inch depth. When it is impractical to mix Treflan with the soil mechanically, remove all germinated and growing weeds and allow the herbicide to be carried into the soil through rainfall or sprinkle irrigation.

Treflan is quite effective on annual grasses, but many broadleaf weeds will need to be mechanically removed.

Other Publications on Weed Control

Copies of the following publications on weed control are available from the office of your county Extension adviser and the Office of Agricultural Publications, 123 Mumford Hall, 1301 West Gregory Drive, Urbana, Illinois 61801.

Calibrating and Adjusting Granular Row Applicators — Circular 1008
Controlling Weeds in the Home Garden — Circular 1051
Equipment and Calibration: Low Pressure Sprayers — Circular 1192
Turfgrass Pest Control — Circular 1076
Herbicides for Commercial Fruit Crops in Illinois — H-659
Herbicide Recommendations for Commercial Nurserymen — NC-2-80
1983 Row Crop Weed Control Guide
Weed Control in Small Grains, Forages, and Pastures

Weed Control in Nursery Crops and Landscape Plantings

David J. Williams

Plan your weed-control program to fit your soil, crops, weed problems, nursery operations, and personal desires. Effective, economic weed control programs combine mechanical methods such as disking, rototilling, and hoeing with the judicious use of herbicides.

Your decisions on herbicide use should be based primarily on the nature and seriousness of your weed problem. Unnecessary and improper use of herbicides can injure or kill nursery crops. When selecting a herbicide, therefore, consider both the risk involved in using the herbicide and the losses caused by the kinds of weeds likely to be present. If cultivation and other good cultural practices are adequate for weed control and are economical, you may not need to use herbicides. Usually, however, the economic benefits from weed control are greater than the adverse effects.

Herbicide performance depends on the weather and on wise application in addition to careful selection. Always apply the herbicide at the time specified on the label and at the correct rate to reduce crop injury. Remember that application rates may vary with soil texture and organic matter.

Much of the risk involved in the use of herbicides can be decreased by heeding the following precautions:

- Apply herbicides only to those crops for which use has been approved.
- Use recommended rates. Applying too much herbicide may damage nursery crops or landscape plants, may cause illegal residues, and is costly. Using too little herbicide can result in poor weed control.
- Apply herbicides only at times specified on the label.
- Wear goggles, rubber gloves, and other protective clothing as suggested by the label.
- Guard against possible injury to nearby susceptible plants such as flowers, vegetables, fruits, or field crops. Mist or vapors from herbicide sprays may drift several hundred yards. The amine form of 2,4-D is safer to use than the volatile ester form, but even the amine spray may drift to susceptible crops. Drift from nonselective postemergence herbicides such as paraquat and glyphosate can damage and sometimes kill ornamental plants. To reduce the chance of damage, calibrate and operate sprayers at low pressure with nozzles that deliver large droplets and high gallonage output. Spray only on a calm day, or make sure air is not moving toward susceptible crops or landscape plants.
- Apply herbicides only when all animals and persons not directly involved in the application have been removed from the area. Avoid unnecessary exposure.

- Check label for proper method of container disposal. Triple rinse, puncture, and haul metal or plastic containers to an approved sanitary landfill. Haul paper containers to a sanitary landfill or burn them in an approved manner.
- Return unused herbicides to a safe storage place. Store them in original containers away from unauthorized persons, particularly children.
- Because manufacturers' formulations and labels are sometimes changed and government regulations modified, always refer to the most recent product label.

This guide has been developed to help you use herbicides as effectively and safely as possible. However, because no guide can remove all risk involved, the University of Illinois and its employees assume no responsibility for results of using herbicides, even if they have been used according to the suggestions, recommendations, or directions of the manufacturer or any governmental agency.

Some herbicides have different formulations and concentrations under the same trade name. *No endorsement of any trade name is implied, nor is discrimination against similar products intended.*

Herbicide Rates

Herbicide rates vary according to the time of application, soil conditions, the tillage system used, and the seriousness of the weed infestations. Rates may vary for postemergence and preemergence use if the herbicide can be used for either purpose. Postemergence rates often vary depending on the size and species of the weeds and on whether an adjuvant is specified. Rates for combinations are usually lower than those for herbicides used alone.

The rates for soil-applied herbicides usually vary depending on the texture of the soil and the amount of organic matter it contains. For instance, light-colored, medium-textured soils with little organic matter, such as occur in much of southern Illinois, require relatively lower rates of most herbicides than do the dark-colored, fine-textured soils with medium to high organic matter that occur in much of central and northern Illinois. For sandy soils the herbicide label may specify "do not use," "use a reduced rate," or "use a postemergence rather than soil-applied herbicide," depending on the herbicide and its adaptation and on crop tolerance.

Preemergence Herbicides

Alachlor: Apply prior to the germination of weed seeds and incorporate lightly into the soil. The 15% G formulation is commonly used in the production of container-grown evergreens. Avoid using on arborvitae. Soil persistence is about six weeks. Excellent for controlling annual grasses. Trade name: Lasso.

Atrazine: This herbicide can be used for weed control in Christmas tree plantations. It should not be applied to newly planted trees. Application can be made after newly planted trees have been adequately watered in. Do not apply on deciduous nursery stock. This herbicide controls a broad spectrum of weed species. Trade names: Aatrex, Atrazine, others.

Bensulide: Apply this herbicide prior to germination of weed seeds and water it into the soil after application. The 12.5% G formulation is commonly used on landscape plantings, including groundcovers. It provides long residual control of weeds. It will control crabgrass, goosegrass, pigweed, lambsquarters and shepherd's purse. Trade names: Betasan, Prefar.

Chloramben: Apply prior to weed seed germination. It controls weeds most effectively when shallowly incorporated into the soil. It moves readily in sandy soils and has an average persistence of six to eight weeks. Commonly used for weed control in beds of annual flowers. Trade names: Amiben, Vegiben, Ornamental Weeder.

Chlorpropham: This herbicide is used primarily for the control of winter annuals such as chickweed. Apply when nursery stock is dormant. This herbicide is used extensively in the fall for chickweed control on a broad spectrum of container-grown nursery crops and in beds of rooted cuttings. Trade names: Furloe, Chloro-IPC.

DCPA: Apply prior to weed seed germination. It will give effective weed control for 10 to 12 weeks. DCPA is most effective in controlling annual grasses such as crabgrass, annual bluegrass, and goosegrass. Apply 10 pounds active ingredient per acre. DCPA can be used on almost any nursery crops as well as on a wide variety of flowering annuals. Trade name: Dacthal.

Dichlobenil: This herbicide controls a broad spectrum of both annual and perennial weeds. Best results are achieved when it is applied in the fall or winter when the soil temperature is below 45° F. If the soil temperature is above 45° F., incorporate the herbicide into the soil. This herbicide is more effective on heavy soils. Apply at four to six pounds active ingredient per acre. Trade name: Casoron.

Diphenamid: Apply prior to weed seed germination. Water it into the soil for improved weed control. Diphenamid leaches readily in sandy soils. It remains in the soil for three to four months and controls crabgrass, annual bluegrass, carpetweed, chickweed, knotweed, lambsquarters, pigweed, purslane, and smartweed. Apply three to four pounds active ingredient per acre. Trade name: Enide.

EPTC: Apply one month before planting and mechanically incorporate or irrigate into the soil. Its residual life is approximately four weeks. It can be used to control annual grasses, annual morningglory, chickweed, lambsquarters, purslane, and pigweed. It will suppress quackgrass and yellow nutsedge. Apply three to four pounds of active ingredient per acre. Trade names: Eptam, Eradicane.

Hexazinone: Apply to Scotch pine when dormant. This herbicide is commonly used by Christmas tree growers who grow pine. Do not apply to newly planted trees. Wait at least two months following planting before applying this herbicide; then apply only if rainfall has settled the soil around the base of the transplant. Do not use on gravelly soil or soils that are more than 85 percent sand. Do not apply to white pine. Apply at one to two pounds active ingredient per acre. Trade name: Velpar.

Metolachlor: Apply prior to weed seed germination. Incorporation can improve yellow nutsedge control. Soil persistence is 10 to 12 weeks. Fall panicum, foxtails, galinsoga, and smartweed are readily controlled by this herbicide. Apply at two to three pounds active ingredient per acre. Use lower rates on fine textured soils. Trade name: Dual.

Napropamide: Apply before the weed seeds germinate. Incorporation into the top one or two inches of soil can enhance weed control. This herbicide will provide good weed control up to three months depending upon environmental conditions. An excellent herbicide for weed control in container-grown crops. It controls annual grasses, chickweed, common groundsel, knotweed, lambsquarters, and purslane. Apply two to three pounds of active ingredient per acre. Trade name: Devrinol.

Oryzalin: Apply prior to the germination of weed seeds. This herbicide does not require mechanical incorporation but should be watered into the soil. The herbicide has an extensive label, listing many species of nursery crops. This herbicide controls crabgrass, annual bluegrass, goosegrass, foxtails, fall panicum, purslane, common groundsel, carpetweed, lambsquarters, pigweed, chickweed, and shepherd's purse. Spring applications usually result in season-long weed control. Apply two to four pounds active ingredient per acre. Trade name: Surflan.

Oxidiazon: Apply before the weed seeds germinate. Oxidiazon controls most weed species except for established perennial weeds and chickweed. It is more effective in container-grown than field-grown nursery crops. Apply four pounds active ingredient per acre. Trade names: Ronstar, Pro Grow Herbicide.

Oxyfluorfen: Apply directly to dormant deciduous nursery stock and evergreens or as a directed spray to actively growing deciduous nursery stock, avoiding the foliage. Oxyfluorfen has both preemergence and postemergence weed control activity. Apply at two pounds active ingredient per acre. Trade name: Goal.

Pronamide: Apply to nursery stock and Christmas trees in the fall for the control of annual and perennial grasses. Apply preemergence or early postemergence. This herbicide is most active on muck or peat soils. Apply at two to four pounds active ingredient per acre. Trade name: Kerb.

Simazine: Apply preemergence or early postemergence. This herbicide is widely used in Christmas tree, evergreen, and shade tree production. It is not used for weed control on container-grown crops. Fall application is a common nursery practice. This will result in the need for a spring herbicide program for season-long weed control. Do not apply to newly planted nursery stock. Apply at two to four pounds active ingredient per acre. Trade name: Princep.

Trifluralin: Incorporation is necessary since this herbicide is degraded by sunlight. This material is used most often as a preplant treatment since its incorporation in to the soil where established plants are growing is difficult, if not impossible, with some species of nursery crops. This herbicide can be used for a large number of flowering annuals and perennials. It controls annual grasses, lambsquarters, pigweed, and purslane. Apply one pound of active ingredient per acre. Trade names: Treflan, Preen.

Postemergence Herbicides

Amitrole: This herbicide is used to control emerged broadleaved weeds. It is applied to the foliage of weeds. Avoid getting this herbicide on the leaves of nursery stock or other desirable vegetation. This material will effectively control poison ivy. Trade names: Amino trizole, Weedazol, many others.

Cacodylic acid: This is a nonselective contact herbicide. It is inactivated on contact with soil. Best results are obtained on young actively growing weeds. It produces top kill only; therefore, repeat applications are necessary for season-long weed control. Apply 2.5 pounds active ingredient per acre. Trade names: Phytar 560, many others.

Dalapon: This herbicide is used to control perennial grasses in noncrop areas. It is grass-selective, but is not as effective as glyphosate on some established perennial grasses such as quackgrass. It has soil activity and is persistent in the soil for approximately five weeks. It is effective on cattails. Apply at 10 to 15 pounds active ingredient per acre. Trade name: Dowpon M.

Glyphosate: This is a nonselective systemic herbicide that is absorbed by the foliage and translocated to the root. It has no residual soil activity. Avoid spraying suckers on shade or fruit trees. Contact with tree bark does not injure the tree. Apply at one pound active ingredient per acre. Trade names: Roundup, Kleenup.

Hexazinone: This herbicide can be used to control herbaceous weeds and deciduous woody plants in conifer plantings. Recommended for use in Scotch pine plantings. Do not use on gravelly soils or soils containing more than 85 percent sand. Do not apply in white pine plantings. Apply at one to two pounds active ingredient per acre. Trade name: Velpar.

Oxyfluorfen: This herbicide has both postemergence and preemergence activity. Postemergence activity is best when weeds are smaller than four inches tall. Henbit, shepherd's purse, sowthistle, pigweed and common groundsel are controlled by postemergence applications of this herbicide. Common groundsel is a problem in container-grown nursery crops. Apply at one-half to two pounds active ingredient per acre. Trade name: Goal.

Paraquat: This is a nonselective contact herbicide that must come in contact with the weed's foliage. It is not translocated to the root; therefore, established perennial weeds will resprout. Control is increased when a nonionic surfactant is used in combination with this herbicide. There is no residual soil activity. Repeat applications are needed for season-long weed control. Apply one-half to one pound active ingredient per acre. Trade name: Paraquat CL.

Herbicide Combinations

The spectrum of weeds controlled can be expanded by using two or more different herbicides in combination with each other or by making sequential applications of different herbicides. Combinations that are tanked-mixed should be in accordance with the label.

If an area is weed free, an application of one or more preemergence herbicides is recommended, followed by mechanical removal or applications of postemergence herbicides as weeds develop.

If an area has weeds, a postemergence herbicide to control existing weeds is needed in combination with a preemergence herbicide to control weeds as they germinate.

Preplant Herbicide Programs

Herbicides applied prior to the planting of a new crop should be incorporated into the top one or two inches of soil. Devrinol, Ronstar, Surflan, and Treflan are labeled for use on new nursery plantings.

Recommended Preemergence Herbicide Programs for Field-Grown Nursery Stock

1. Preemergence herbicides can be used alone in accordance with their label regarding crop and time of application.

2. A fall application of Princep followed by a spring application of either Devrinol, Dual, Lasso, or Surflan. This program is commonly used for shade trees and evergreens.

3. A spring application of Princep in combination with either Devrinol, Dual, Lasso, or Surflan.

Recommended Preemergence Herbicide Programs for Container-Grown Nursery Stock

1. Preemergence herbicides can be used alone in accordance with their label regarding crop and time of application.

2. A fall application of Furloe followed by a spring application of either Devrinol, Ronstar, Surflan, or a combination of Devrinol and Ronstar.

3. A late fall or winter application of Casoron followed by a spring application of either Devrinol, Ronstar, Surflan, or a combination of Devrinol and Ronstar.

Preemergence Herbicides: Names and Some Commercial Formulations

Common name	Trade name	Formulation[a]
alachlor	Lasso	4% E, 15% G
atrazine	Aatrex, Atrazine, others	4% L, 80% L, 80% WP, 90% WDG
bensulide	Betasan, Prefar	4% E, 12.5% G
chloramben	Amiben, Ornamental Weeder, Vegiben	2% E, 10% G
chlorpropham	Furloe, Chloro-IPC	4% E, 20% G
DCPA	Dacthal	5% G, 75% WP
dichlobenil	Casoron	4% G, 10% G, 50% WP
diphenamid	Enide	5% G, 50% WP, 80% WP
EPTC	Eptam, Eradicane	7% E, 10% G
hexazinone	Velpar	90% SP, 25% WDL
metolachlor	Dual	8% E, 15% G
napropamide	Devrinol	2% E, 50% WP, 5% G, 10% G
oryzalin	Surflan	4% F, 75% WP
oxidiazon	Ronstar	2% G

Preemergence Herbicides: Names and Some Commercial Formulations (Cont.)

Common name	Trade name	Formulation[a]
oxyfluorfen	Goal	2% E
pronamide	Kerb	50% WP
simazine	Princep	4% G, 4% L, 80% WP, 90% WDG
trifluralin	Treflan, Preen	4% E, 5% G

[a]E = emulsifiable concentrate, G = granular, L = liquid, WP = wettable powder, WDG = water dispersible granular, SP = soluble powder, WDL = water dispersible liquid, and F = flowable.

Postemergence Herbicides: Names and Some Commercial Formulations

Common name	Trade name	Formulation[a]
amitrole	numerous	numerous
cacodylic acid	Phytar 560, many others	numerous
dalapon	Dowpon M	75% WSP
glyphosate	Roundup, Kleenup	4% E
hexazinone	Velpar	90% SP, 25% WDL
oxyfluorfen	Goal	2% E
paraquat	Paraquat CL	2% E

[a]E = emulsifiable concentrate, SP = soluble powder, WDL = water dispersible liquid, WSP = water soluble powder.

Controlling Weeds in the Home Garden

H.J. Hopen

A weed is a plant growing where it is not wanted. Weeds compete with desirable plants for water, soil nutrients, sunlight, and gaseous components of the air needed for growth. Many weeds also harbor diseases and insects that may attack plants around the home.

Three general methods of weed control can be used in the home garden: (1) cultivation and mechanical removal (hoeing, pulling, etc.); (2) mulching (smothering of weeds); and (3) herbicides (weed killers). Usually, one or more of these methods are used.

Cultivation and Mechanical Removal

Cultivation and mechanical removal is the safest and most common method for controlling weeds in small home gardens. Since only those weeds that are actually present can be controlled, the process must be repeated several times throughout the growing season. It may be difficult to control weeds adequately during vacations or busy work periods with this method.

Weeds should be shaved off with a sharp hoe while gently breaking up the crust. Deep tillage causes severe injury to many shallow-rooted plants and helps place a fresh supply of weed seeds in position to germinate. Keeping equipment sharp and in good condition will help reduce injury to desirable plants. Hoe carefully around your plants and hand pull weeds close to the plants.

Weeds can be controlled by wheel and hand hoes in smaller areas or by power equipment such as rototillers and garden-type tractors in large gardens. This equipment should be set shallow when used in a garden for weed control.

Mulching

Mulching controls weeds by preventing light from reaching the weed seedlings. This method will control annual weeds—those that germinate from seed each year for several weeks. Perennial weeds (those that sprout each year from below-ground plant parts) usually must be removed by cultivation or hoeing.

Organic Mulches

The organic materials most frequently used for mulching include plant residues such as straw or hay (free of weed seeds); crushed corncobs; various nut hulls; leaf and grass composts; peat; wood products such as sawdust, wood chips, shredded bark, and shavings; and well-rotted animal manures. Use the most economical mulch available. A combination of several thicknesses of newspaper (use papers with black ink, not colored ink) covered by organic materials has shown promise as a summer type of mulch. To function effectively, these materials should be applied at a depth of about four to six inches.

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Natural mulch materials may require considerable hand labor for application. Most organic materials are bulky and must be hauled to the place of use. This is not a serious problem for small gardens.

Organic mulches return organic matter and some plant nutrients to the soil and improve soil tilth as they decompose. Added benefits are prevention of soil compaction, conservation of soil moisture, erosion control on slopes, cooler summer soil temperatures, and the added attractiveness of the garden. Mulches such as colored stones and decorative barks are available for flower and ornamental plantings.

When organic materials are used, you may need to add nitrogen fertilizer to prevent a deficiency of nitrogen in the mulched crop. With legume mulches (alfalfa or clover), however, excess nitrogen is released during decomposition.

Organic mulch material	Nitrogen required for decomposition (pounds per ton of mulch)
Cocoa pods	6.0
Corncobs, ground	22.5
Hay, grass	7.6
Peanut hulls	8.5
Sawdust, fresh	26.0
Wheat straw	17.6

Synthetic Mulches

Common synthetic mulches include polyethylene, paper, paper-polyethylene combinations, wax-coated papers, and aluminum and steel foils.

Polyethylene film is used in a thickness of 1 to 1 1/2 mils (0.001 inch = 1 mil) and a width of three to six feet. Black polyethylene is preferable for the home vegetable garden because it prevents light from reaching the weed seedlings. It is generally not practical to use transparent polyethylene as a full season mulch because weed problems develop under the polyethylene.

Press the edges of the mulch down into furrows and cover firmly with soil. Do not throw excess soil on top of the mulch. A push-type, one-wheel cultivar works well to open and close furrows. The mulch may also be installed by using a rake or shovel to cover the edges with soil.

It is better to apply synthetic mulches in crop rows rather than attempt to cover the entire area. The area between the rows of polyethylene mulch must be carefully cultivated and hoed.

The advantages of polyethylene mulching include moisture conservation, increased spring soil temperatures, and keeping edible aboveground plant portions clean.

Herbicides

It is not a good practice to use herbicides in small ornamental and vegetable gardens containing several crop species because different flowers, vegetables, and weeds vary in their tolerance to herbicides. Some herbicides may remain in the soil longer than one growing season and may kill or injure some species the following year (especially if excessive rates are used). Ideally, a specific herbicide should be used for each crop species, but most people have small areas of several species in their gardens, and it would often be impractical and expensive to buy the several herbicides that would be needed.

Application methods must be carefully controlled when a herbicide is used on small areas. The tendency is to apply additional amounts if the quantity measured out "looks" as if it is not enough. A low percentage granular formulation is suggested for small garden areas. *Check rates of material to use and application techniques on the container label very carefully. Applications must be accurate and uniform. Excessive amounts may cause injury to the present or subsequent crops.*

If a gardener is unwilling to remove weeds by hand in the home garden, Dacthal, Amiben, Treflan, or Eptam can be used on several species. These herbicides may not be the most effective for a large planting of the individual fruit or vegetable species. Herbicides for these large plantings are listed in the commercial growers' recommendations (see Extension Circular 907, *1983 Weed Management Guide for Commercial Vegetable Growers*, or Horticulture Fact Sheet H-659, *1983 Herbicides for Commercial Fruit Crops in Illinois*).

Herbicides may be sold under several trade names. If you cannot identify the trade names on the container, look for the common name or chemical name on the label. The trade names listed are for products commonly used in Illinois. Products of identical content marketed under other trade names may be equally acceptable.

Trade name	Common name	Chemical name
Dacthal	DCPA	dimethyl 2,3,5,6-tetrachloroterephthalate
Roundup, Kleen Up	glyphosate	N-(phosphonomethyl) glycine
Treflan, Preen	trifluralin	α,α,α-trifluoro-2,6 dinitro-N-N-dipropyl-p-toluidine
Amiben, Weedone Garden Weeder	chloramben	3-amino-2,5-dichlorobenzoic acid
Eptam	EPTC	ethyl N,n-dipropylthiol carbamate
Basfapon, Dowpon (and others)	dalapon	2,2 dichloropropionic acid

Dacthal

Dacthal is a preemergence (before the weeds emerge) herbicide that must be applied to weed-free soil. It controls very small weed seedlings soon after the weed seeds germinate. The herbicide action is most effective if rainfall occurs or the soil is irrigated within two to three days after application of the herbicide.

Dacthal is available as a 75 percent wettable powder that can be used for large garden areas and as a five percent granular material for smaller areas. This material can be used for annual grass control in lawns, on a number of species of flowers, and on strawberries, broccoli, brussels sprouts, cauliflower, cabbage, dry and snap beans, cucumbers, squash, melons, collards, kale, mustard greens, turnips, garlic, onions, potatoes, sweet potatoes, yams, tomatoes, eggplants, peppers, and horseradish.

Do not use Dacthal on beets, bugle weed, button pink, carnation, geum, germander, mesembryanthemum, pansy, phlox, sweet william, and telanthera.

A one-time application to all species is not always possible in a garden of flowers or vegetables because some plants are susceptible to injury in early growth stages. It is preferable to use Dacthal at seeding or transplanting time if the species is adapted for it. When this is not possible, the weeds should be removed and Dacthal applied to prevent further weed development. Consult the container label for the appropriate application time.

Dacthal is effective in controlling annual grasses that are a problem in the spring. Those broadleaf weeds that escape control should be mechanically removed.

Dacthal is the best *multipurpose* herbicide for home-garden use.

Treflan

Since Treflan is used in soybean culture in Illinois, it is widely available. It can be purchased as a liquid with four pounds of active ingredient per gallon for large garden areas or as a low percentage granular for smaller areas.

Treflan can be used for weed control in green, lima, and dry beans, broccoli, brussels sprouts, cabbage, cauliflower, carrots, kale, mustard greens, okra, peas, peppers, tomatoes, and turnip greens, or in growing apricots, cherries, grapes, peaches, and plums. Established trees, some ornamentals, and many established flowers will tolerate Treflan. *Do not use* on ground covers, sweet corn, strawberries, bramble fruits, or blueberries, since injury may result.

Treflan must be mixed with or watered into the soil to prevent loss of the chemical from the soil surface. A rototiller or similar equipment should be used to mix Treflan with the soil to a three- to four-inch depth. When it is impractical to mix Treflan with the soil mechanically, all germinated and growing weeds should be removed and the herbicide carried into the soil through rainfall or sprinkle irrigation.

The amount of Treflan to use is correlated very closely with the type of soil. The appropriate amounts are shown on the container label.

Treflan is quite effective on annual grasses, but many broadleaf weeds will need to be mechanically removed.

Amiben

Amiben is also available to many farmers because it is used in soybean culture. It should be applied to the soil surface before weed seeds germinate. The herbicide action is most effective if rainfall occurs or the soil is irrigated two to three days after application of the herbicide.

Amiben is available as a liquid with two pounds of active ingredient per gallon for large garden areas and as a low percentage granular material. It can be used on young asparagus beds when they will not be harvested, lima beans, pumpkins and squash, sweet potatoes, and transplanted tomatoes and peppers. It can be used on cucumbers, green beans, and muskmelons, but some injury may occur on these vine crops. *Do not use* on other vegetable or fruit crops.

As indicated on the container label, a number of annual flowers and established shrubs will tolerate Amiben. Amiben controls a wider range of annual grass and broadleaf weeds than Dacthal, Treflan, or Eptam, but it is not as effective on common purslane, which is often a problem in home gardens.

Amiben should not be used on gardens in sandy soil.

Eptam

Eptam can be purchased as a liquid with seven pounds of active ingredient per gallon for large gardens or as 10 percent granular material for smaller areas. It can be used for weed control in green or dry beans, and Irish potatoes.

Eptam is not persistent in the soil. It must be mixed with or watered into the soil immediately after application to prevent loss of the chemical from the soil surface. A rototiller or similar equipment should be used to mix Eptam with the soil to a three- to four-inch depth. When it is impractical to mix it with the soil mechanically, all germinated and growing weeds should be removed and the herbicide carried into the soil through rainfall or sprinkle irrigation.

Eptam is quite effective on annual grasses, but many broadleaf weeds will need to be mechanically removed.

Perennial Weed Control

Cultivation and mulching do not control most perennial weeds. One method of control would be to remove the top growth to deplete the underground storage tissues. This method may suppress the growth of perennial weeds, but completely eradicating the weeds in this way is *very* difficult.

Glyphosate (Roundup, Kleen Up) must be applied to green, actively growing plants to be effective. It can be applied in the early spring, as it is nonpersistent. Glyphosate can also be applied in the fall, after the edible plants have been removed from the garden, but while the perennial weeds are still growing. Do not apply glyphosate to or let it drift onto desirable or edible plants since it is nonselective. Be sure to read the label for complete application instructions.

Glyphosate can be used to control perennial weeds in vegetable gardens where labeled vegetable species will be grown. It must *not* be applied when nonlabeled vegetable species are to be grown. If gardeners in areas that are infested with perennial weeds are willing to restrict their choice of crops for one year, this method can effectively reduce the weeds. To find out which species are labeled, check the glyphosate label or ask your Extension adviser.

Precautions

General

Phenoxy herbicides (2,4-D and others) and Banvel (dicamba) are used to control broadleaf weeds in corn, turf areas, and roadways. Most flowers, shrubs, small fruits, tree fruits, and vegetables are susceptible to injury by these herbicides. When applying these materials, be sure that spray, drifting spray, or fumes do not reach susceptible plants.

Use the amine formulation of 2,4-D, which is less volatile and does not drift as easily as the esters, and apply it under as calm conditions as possible. A sprayer used to apply phenoxy herbicides or Banvel on grass should not be used to apply other pesticides on gardens. Phenoxys usually cannot be cleaned out of sprayers thoroughly enough to avoid injury to broadleaf plants.

Soil Deactivation

If a garden area becomes contaminated with a persistent herbicide or a soil sterilant, this area can be decontaminated by applying activated carbon to inactivate the herbicide.

Disposal of Pesticide Containers and Surplus Pesticides

Use pesticides safely—read the label. If pesticides are handled or applied improperly, or if unused parts are disposed of improperly, they may be injurious to humans, domestic animals, desirable plants, pollinating insects, and fish or other wildlife, and they may contaminate water supplies. Use pesticides only when needed and handle them with care. Follow the directions and heed all precautions on the container labels.

Store all pesticides in a cool, dry, locked storage area so that they are not accessible to children, irresponsible persons, and animals. Do not dispose of pesticides through sewage systems. Haul them or have them hauled to a sanitary land fill for burial.

Never place pressure cans on a stove or heater or near any source of heat that might exceed 120°F. Store in a cool place—not in the hot sun. Have empty pressure cans hauled away and buried by experienced disposal crews. *Do not incinerate.*

Classification of Herbicides

The U.S. Environmental Protection Agency is classifying herbicides for *general use* or *restricted use*. An Illinois resident wishing to use a herbicide classified for restricted use must be certified as a private or commercial pesticide applicator by the Illinois Department of Agriculture. Your county Extension adviser in agriculture can give you details on this program. None of the herbicides discussed in this paper have been classified for restricted use.

Controlling Weeds in Noncrop Areas

Total vegetation management is the application of nonselective chemicals or nonselective rates of selective chemicals as a means of controlling all vegetation in such noncrop areas as parking lots, drive-in theaters, driveways, patios, and certain industrial sites.

Herbicides can be classified by their length of control. Those with little or no residual activity are the fumigants and the contact herbicides. Fumigants are volatile materials that can affect the viability of weed seeds as well as existing growth. Contact herbicides, such as paraquat, control only the existing vegetation that the spray contacts.

Amitrole, dalapon, 2,4-D, and DSMA give temporary control for four months or less. Semipermanent control is provided by some inorganic salts, such as sodium borate and sodium chlorate. Organic compounds that provide semipermanent control are the uracils (bromacil), substituted ureas (monuron, diuron, and tebuthiuron), and the triazines (atrazine, simazine, and prometon).

Areas where total vegetation management is desirable include the following: (1) beneath asphalt pavement, (2) along railroads, (3) around buildings as a means of preventing the growth of weeds that are unsightly or present a fire hazard, and (4) along fences to control weeds. As an alternative to chemical control, it may be preferable to establish desirable, competitive vegetation along a fence to discourage weed growth and to provide protective soil and wildlife cover. Short-term herbicides, such as 2,4-D and dalapon, might be used for temporary control until desirable vegetation can be established.

Precautions and General Procedures

Several precautions must be observed when you use nonselective chemicals. You must know what weeds are to be controlled and select the correct chemical for those particular problems. A survey of the area must be made, noting any desirable vegetation in the immediate or adjacent areas that could be affected by spray drift, chemical runoff, or leaching into the root zone.

Appropriate precautions should be taken to prevent damage to desirable plants. The risk of injury with some of these materials may be too great to allow their use in some areas, so be certain that you are familiar with the product and aware of the risks before using these materials. Some treatments should be made only by professional applicators.

The type of vegetation to be controlled will affect your decision in selecting a chemical. Perennial grasses can be controlled with dalapon, amitrole, pronamide, or DSMA; woody perennials, with 2,4,5-T*, silvex*, or picloram. Deep-rooted vines, such as bindweed, can be controlled with fenac, dicamba, or picloram.

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*2,4,5-T and silvex are currently under emergency suspension by the U.S. Environmental Protection Agency.

Application timing is very important. The best time to apply nonselective, soil-residual herbicides is early in the spring before herbaceous weeds have emerged. If vegetation is heavy, it may be necessary to remove existing vegetation or to add a contact or foliar herbicide or mix the herbicides with diesel fuel to speed top-kill. After existing vegetation is under control, the rate can be reduced for maintenance applications in the future.

Adjust the application rates according to the soil types or for the desired length of control. When you want to control growth for two or three years, maintenance applications are better than an initial application that is too high.

Herbicides for Noncropland

Inorganic Compounds

1. Sodium chlorate has both foliar and root activity. This compound, however, presents an extreme *fire hazard*, so fire retardants such as calcium chloride or the borates are often added to reduce the hazard. Altacide is sodium chlorate with a fire retardant. Another drawback to sodium chlorate is the fact that it may be toxic to livestock that seek its salty taste. The rate is 500 to 1,000 pounds per acre.

2. Sodium borate (Borax, Polybor) has primarily root activity. Very high rates are required (1 to 2 tons per acre), so it is often used only as a granular carrier for organic compounds.

3. Sodium arsenite is a *highly toxic* compound. It is not usually recommended because safer products are now available. Sodium arsenite is formulated as a 9.5-pound-per-gallon liquid. The rate is 55 to 110 gallons per acre.

4. Ammonium sulfamate (Ammate-X) is formulated as 95-percent soluble crystals for weed control on woody plants and herbaceous weeds. It is sometimes used for brush control where volatilization of phenoxy herbicides would be a hazard. It is corrosive to metals. The rate is 60 to 100 pounds per acre.

Organic Compounds for Long-Term Control

1. Asulam (Asulox) is a 3.34-pound-per-gallon formulation that is used at the rate of 1 to 2 gallons per acre. It controls grasses better than broadleaf weeds.

2. Bromacil (Hyvar-X) has both foliar and soil activity. It is formulated as an 80-percent wettable powder (WP) and a 2-pound-per-gallon liquid. The rate of active ingredient is 5 to 15 pounds per acre. Urox-'B' is a 4-pound-per-gallon liquid of bromacil.

3. Bromacil + diuron (Krovar I) is formulated as an 80-percent, 1:1 combination of bromacil:diuron. It is used to control shallow-germinating weeds and deep-rooted perennials. The rate is 6 to 30 pounds per acre. Krovar II is a 2:1, bromacil: diuron formulation.

4. Simazine (Princep) is formulated as an 80-percent WP, a 4-pound-per-gallon liquid, and a 4-percent granule. It has little foliar activity but has a longer residual control than atrazine. The rate is 5 to 40 pounds per acre of the 80-percent WP.

5. Atrazine is an 80-percent WP or a 4-pound-per-gallon liquid. Atratol 8P is 8-percent atrazine on a chlorate-borate pellet. The rate is 5 to 40 pounds per acre of the 80-percent WP or 0.25 to 1 pound per 100 square feet of the pellet.

6. Prometone (Pramitol) is available as a 2-pound-per-gallon liquid, an 80-percent WP, and a 5-percent pellet. It has more foliar activity than atrazine. The rate for the liquid is 5 to 30 gallons per acre. For the pellets, the rate is 12.5 to 75 pounds per acre or 0.5 to 2 pounds per 100 square feet.

7. Hexazinone (Velpar) is available as a 90-percent water-soluble powder (SP), a 25-percent water-dispersible liquid (WDL), and as 20- or 10-percent pellets. Apply 2 to 5 pounds SP or 1 to 2 1/2 gallons WDL per acre for contact kill and short-term control and 6 to 12 pounds SP or 3 to 6 gallons WDL for season-long control. The gridball formulations are recommended at 1 to 4 pounds active ingredient per acre.

8. Tebuthuiron (Spike) is available as an 80-percent WP and as a 1 or 5 percent G. Apply before or during periods of active growth at a rate of 5 to 20 pounds per acre.

9. Diuron (Karmex) is an 80-percent WP. The rate is 10 to 60 pounds per acre. It is sometimes mixed with bromacil (see no. 3).

10. Dichlobenil (Casoron) is available as a 50-percent WP and a 4-percent pellet. It is more commonly used for nursery weed control than for soil sterilization. The rate is 10 to 40 pounds per acre of the 50-percent WP.

11. Amizine is a combination of amitrole and simazine, bringing together the foliar activity of amitrole with the residual activity of simazine. The suggested rate for general vegetation control is 20 pounds or 18 gallons of Amizine in 100 gallons of water per acre.

Many of the granular or pelleted materials are organic herbicides formulated on sodium borate or borate-chlorate granules. They can be applied dry, which is often convenient for spot treatment or application on small areas.

Organic Herbicides for Short-Term Control

1. Amitrole is available as Weedazol and Amino Triazole. It is a translocated herbicide that is especially effective on poison ivy and Canada thistle as well as perennial grasses such as quackgrass. Amino Triazole is a 90-percent soluble powder and is applied at a rate of 2 to 5 pounds per acre. Weedazol is a 50-percent soluble powder and is applied at a rate of 2 to 8 pounds per acre.

2. Amitrole-T is available as Cytrol and Amitrol-T with 2 pounds per gallon of amitrole plus ammonium thiocyanate. Since Amitrole-T is formulated as a liquid, it is sometimes considered more convenient to handle than amitrole. The rate is 1 to 3 gallons per acre.

3. Dalapon (Dowpon-M) is a foliar-applied, systemic grass killer. It is also available with TCA (Dowpon-C, Revenge) for longer residual control. The rate is 10 to 15 pounds per acre of the 85-percent soluble powder. A wetting agent improves the control. Perennial grass may require more than one application.

4. Sodium-TCA is a root-absorbed grass killer that remains in the soil longer than dalapon. It is a 90-percent soluble powder used at 50 to 150 pounds per acre.

5. MSMA is available as Daconate, a 6-pound-per-gallon liquid with surfactant. It is used for perennial grass control at 0.5 to 1.5 gallons per acre. More than one application may be necessary.

6. DSMA is available as a liquid or soluble powder. It is frequently used for spot treatment of johnsongrass. The rate is 3 to 9 pounds per acre of the soluble powder or 1 to 2 gallons per acre of the liquid.

7. Paraquat is a 2-pound-per-gallon contact herbicide with little residual activity. The volume of water should be adjusted to the amount of vegetation. The rate is 1 to 3 quarts per acre. A surfactant is added at the time of application. Paraquat is restricted to use by certified applicators.

8. Glyphosate (Roundup) is available as a 4-pound-per-gallon systemic herbicide that is nonpersistent. Unlike paraquat, it will translocate to kill perennial weeds. The rate is 1 to 5 quarts per acre.

9. Dinoseb ("dinitro") is a contact herbicide often mixed with fuel oil. It is *quite toxic* and will stain clothes and skin. Mix 1 to 2 quarts per 30 to 50 gallons of fuel oil with enough water to make a total volume of 100 gallons.

Herbicides for Broadleaf Weed and Brush Control

1. Dicamba (Banvel) is available as a 2- or 4-pound per gallon formulation, or as 5 percent granules. The Banvel II formulation is less subject to vapor drift than Banvel, but both present a hazard to nearby soybeans, tomatoes, and desirable woody plants. The rate is 1 to 4 quarts per acre Banvel and 2 to 8 quarts per acre of Banvel II.

2. Picloram (Tordon) is a persistent, broadleaf herbicide. It is formulated as liquid Tordon K or pelleted Tordon 2K or 10K. Mixtures with 2,4-D are Tordon 101, to be applied to stems and foliage, and Tordon 101R or RTU, which is formulated for cut-surface treatments. Special care must be taken because of picloram's soil mobility and long soil life. Tordon is restricted to use by certified applicators.

3. Fenac is closely related to 2,3,6-TBA in terms of controlling deep-rooted, perennial broadleaf weeds. It is formulated as a 1.5-pound-per-gallon liquid. The application rate is 2 to 15 gallons per acre.

4. 2,4-D is a broadleaf herbicide with short persistence. Amine formulations present less hazard to nearby sensitive plants than ester forms. The common formulation is as a 4-pound-per-gallon liquid. Mixtures of 2,4-D and dalapon are often used for short-term control of both broadleaf and grass weeds.

5. 2,4,5-T is similar to 2,4-D but gives better control of some woody plants and has a longer soil life. Mixtures of 2,4-D and 2,4,5-T are commonly called "brush-killer." The common formulation is as a 4-pound-per-gallon liquid. This material is under emergency suspension as of March 1, 1979.

6. Dichlorprop (Weedone 2,4-DP) may be used for brush control in a manner similar to that for 2,4,5-T.

7. Silvex (Kuron, 2,4,5-TP) may be used for control of brush in a manner similar to that for 2,4,5-T. This material is currently under emergency suspension as of March 1, 1979.

8. Bromacil (Hyvar-XL) is a 2-pound-per-gallon liquid for basal spraying of brush. A 10-percent pellet (HABCO-10B) is also available.

9. Krenite is available as a 4-pound-per-gallon formulation. When it is applied within two months of leaf senescence, no symptoms are evident until the following spring. Because it does not translocate, it can be used for chemical trimming. The rate is 1.34 to 3 gallons per acre.

Long-Term Residual Control

Spray Applications

Many of these chemicals are WP's and will require thorough agitation for spray application. The rates listed are for the different types of weeds to be controlled. Initial applications are often made at the higher rate, with subsequent treatments at the lower rate.

Herbicide	Rate of formulation per acre: Annuals	Shallow perennials	Deep perennials
AAtrex (80W)	6 to 12.5 lb.	12.5 to 25 lb.	25 to 50 lb.
Amizine (60 W)	6 lb.	12 lb.	20 lb.
Asulox (3.3 lb./gal.)	1 to 2 gal.	1 to 2 gal.	---
Casoron (50W)	8 to 12 lb.	12 to 25 lb.	25 to 40 lb.
Hyvar-X (80W)	3 to 6 lb.	7 to 12 lb.	15 to 30 lb.
Hyvar-XL (2 lb./gal.)	1.5 to 3 gal.	3 to 6 gal.	6 to 12 gal.
Karmex (80 W)	5 to 20 lb.	20 to 40 lb.	20 to 60 lb.
Krovar I (80 W)	4 to 6 lb.	7 to 18 lb.	19 to 40 lb.
Pramitol 25E (2 lb./gal.)	5 to 7.5 gal.	7.5 to 15 gal.	15 to 30 gal.
Princep (80W)	6 to 12.5 lb.	12.5 to 25 lb.	25 to 50 lb.
Sodium chlorate	300 to 500 lb.	500 to 750 lb.	750 to 1,300 lb.
Spike (80W)	5 to 10 lb.	10 to 20 lb.	---
Velpar (90 W)	2 to 5 lb.	6 to 12 lb.	---
Velpar L (2 lb./gal. WDL)	1 to 2.5 lb.	3 to 6 lb.	---

Granular or Pellet Application

Granulars are often more convenient for spot treatment and for small areas. Many granules are on a sodium chlorate—borate base.

Herbicide	No. of lbs./1,000 sq. ft.
Atratol 8P	5 to 10
Banvel G	2.3 to 4.6
Casoron-10P	5 to 10
Chlorea-3	10 to 20
Concentrated Borascu	40 to 60
Pramitol 5P	10 to 20
Princep 4G	5 to 25
Sodium chlorate—borate	30 to 40
Sodium chlorate—modified	20 to 40
Spike 1G	5 to 14
Urox—'HX'	7 to 14
Velpar Gridball	0.2 to 0.9
Velpar Gridball 1cc	0.1 to 0.5

Broadleaf Weeds

These weeds are often best controlled with foliar applications. Deep-rooted perennials can usually be controlled best when they are at the early bud to early bloom stage. The herbicides listed below can move through the air and damage nearby desirable broadleaf plants. They are quite soluble and mobile in the soil and can move into the soil and damage trees or other desirable shrubs and broadleaf plants.

Herbicide	Rate of formulation per acre: Annual and shallow perennials	Rate of formulation per acre: Deep-rooted perennials
Banvel (dicamba)	0.5 to 1 qt.	1 to 4 qt.
Fenac	2 to 5 gal.	10 to 15 gal.
Roundup	1 to 3 qt.	4 to 6 qt.
Silvex*	1 to 2 qt.	2 to 4 qt.
Tordon 101 (picloram + 2,4-D)	2 to 3 qt.	1 to 3 gal.
2,4-D and/or 2,4,5-T*	1 to 2 qt.	2 to 4 qt.

*2,4,5-T and silvex are currently under emergency suspension by the U.S. Environmental Protection Agency.

Undesirable Woody Plants

Most of the materials used to control woody plants are applied to the foliage, but they can be applied (1) as basal bark treatments if the trees are less than 3 inches in diameter or (2) as a frilled treatment if the trees are larger. The basal treatment can be applied in fuel oil during the dormant season. Foliar treatments are usually applied as soon as the brush or trees have leaves fully expanded.

Herbicide	Method of application	Rate of formulation
Ammate-X (ammonium sulfamate)	Foliar	60 lb./A.
Banvel (4 lb./gal. dicamba)	Foliar	2 to 4 qt./A.
Garlon 3A (44.4 percent triclopyr) . .	Foliar	2 to 3 gal./A.
Garlon 4 (61.6 percent triclopyr) . .	Foliar or basal	4 to 8 qt./A.
Krenite (4 lb./gal.)	Foliar	1.5 to 3 gal./A.
Silvex*	Foliar or basal	2 to 4 qt./A.
Tordon 101 (picloram + 2,4-D)	Foliar or basal	1 to 4 gal./A.
2,4,-D and/or 2,4,5-T*	Foliar or basal	2 to 4 qt./A.

*2,4,5-T and silvex are currently under emergency suspension by the U.S. Environmental Protection Agency.

Weedy Grass Control

Weedy grass control is often best accomplished with the herbicides listed below. The use of a spreader-sticker (surfactant) often helps.

Herbicide	Rate of formulation per acre: Annuals	Rate of formulation per acre: Perennials
Asulox	1 to 2 gal.	1 to 2 gal.
Cytrol, Amitrol-T	1 gal.	2 to 3 gal.
Daconate	2 to 3 qt.	3 to 5 qt.
Dowpon	5 to 10 lb.	10 to 30 lb.
MSMA, DSMA	1 to 2 qt.	2 to 4 qt.
Roundup	1 to 2 qt.	2 to 5 qt.
Sodium-TCA	20 to 50	100 to 150

Contact Weed Control

Contact herbicides kill the plant tissue with which they come in contact; thus, adequate spray volume is needed for full coverage. The use of a surfactant often helps the spray to spread on the plants.

Herbicide	Rate per acre
Fuel oil + dinoseb	50 gal. + 2 qt.
Herbicidal naphtha	30 to 50 gal.
Paraquat	1 to 3 qt./A.

Comments

Availability, formulations, trade names, and federal clearance for the use of herbicides change from time to time. Always refer to the most recent product labels for precautions, directions for use, and rates to use. Use herbicides with appropriate precautions to avoid injury to desirable vegetation, to protect the user, and to assure the safety of humans and animals. Store herbicides properly so that children and those who may not be responsible for their actions do not have access to them. Store herbicides only in the original, well-marked containers. Properly dispose of used herbicide containers and old herbicides.

Although both benefits and risks are associated with the use of herbicides, if you use them properly, the benefits can far exceed the risks, and the quality of our environment can be improved by controlling undesirable vegetation. Do not neglect the opportunities for using desirable vegetation to compete with and replace undesirable vegetation. Also, for some areas mechanical control may sometimes be quite practical and the most appropriate method.

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Brush Control in Illinois

The control of brush or undesirable woody plants is required in many situations. Brush control is often used to improve pastures and recreational areas, and to maintain fence-rows, drainage-ditch banks, roadsides, and right-of-ways. Brush can be controlled by mechanical means such as cutting or digging, by herbicide treatments, or with a combination of mechanical and chemical control measures that remove the plant and prevent resprouting.

Mechanical control is costly and time-consuming. And because resprouting often occurs, retreatment may be required for complete control.

Herbicides are often used for brush control because they are less time-consuming than mechanical control methods. Complete control can be achieved with one treatment if the control program is carefully planned, although using chemical control alone allows dead plants to remain. The potential of injury from spray drift or runoff is an important consideration when using herbicides to control brush. Many brush herbicides are selective enough that they leave grasses unharmed while controlling brush and broadleaf weeds. Nonselective herbicides can be used in spot treatments to leave desirable species adjacent to the brush unharmed. Some herbicides have grazing and harvest restrictions. Others cannot be applied to aquatic areas. Be sure to follow label restrictions and recommendations closely.

Method of Application

Various methods can be employed to get the herbicide into the target plant. Table 1 indicates label clearances for methods of applying common brush herbicides.

Foliar treatments are most effective when applied to fully developed plant foliage during late spring or early summer. Some herbicides can be applied throughout the growing season although translocation may be restricted by adverse temperature or moisture stress. Good foliar coverage is necessary for control.

The effectiveness of most foliar treatments will be reduced if rainfall occurs on the day of treatment. Foliar-stem treatments are usually applied only to brush or small trees. Large trees should be treated by another method to improve control and reduce drift potential.

Take precautions against particle drift from the spray to nearby susceptible plants when using the foliar-stem method. Herbicide labels list sensitive species and areas you should avoid spraying. Avoid spraying when the wind velocity is greater than 5 mph or when the wind is blowing toward sensitive crops or ornamentals. Reduce the pressure and use nozzles with larger orifices to apply treatments that do not require coverage with fine spray droplets to achieve good control. Drift-reducing spray additives and equipment are available, but to use them successfully you must adhere closely to the directions. Follow all label precautions and directions to achieve good control and ensure minimum drift.

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Table 1. Label Clearances for Common Brush Herbicides

	Area				Application				Type of brush	
Brush herbicide	Pasture	Drainage-ditch bank	Right-of-way	Noncrop	Foliar-stem spray	Cut surface or injection	Basal bark[a]	Soil	Deciduous	Conifer
2,4-D amine	x	x	x	x	x	x			x	
2,4-D ester	x	x	x	x	x	x	x		x	
2,4-DP (dichlorprop)			x	x	x	x	x		x	
Weedone 170 (2,4-D ± dichlorprop)		x	x	x	x	x	x		x	
Banvel ± 2,4-D	x	x	x	x	x	x	x[b]		x	x
Banvel 5G or 10G	x	x	x	x				x	x	x
Tordon 10K	x		x	x				x	x	x
Tordon ± 2,4-D			x	x	x	x			x	x
Garlon ± 2,4-D			x	x	x	x	x		x	x
Trimec 352 (2,4-D + mecoprop + dicamba)		x	x	x	x				x	
2,4,5-T ± 2,4-D				x	x	x	x		x	
Silvex ± 2,4-D				x	x	x	x		x	
Ammate X	x	x	x	x	x	x			x	x
Krenite		x	x	x	x				x	
Amitrole ± T		x	x	x	x				x	
Roundup			x	x	x				x	
Hyvar-X		x[c]	x	x	x			x	x	x
Velpar			x	x	x			x	x	
Spike			x	x				x	x	x

[a]oil-soluble forms only
[b]not for pasture use
[c]soil application only

Basal-bark treatments are oil-soluble herbicides in a carrier of diesel oil or kerosene. They are applied to the lower 18 inches of brush plants that are less than 5 inches in diameter. The spray should thoroughly drench the stem so that runoff soaks the ground line and all exposed roots. The herbicides commonly used for basal-bark treatments can cause injury if the vapor drifts to desirable crops or ornamentals. Although basal-bark treatments can be made throughout the year, treatments made during the dormant season are less likely to produce drift injury. Basal-bark treatments are labor intensive but are useful in selectively removing undesirable species from stands of desirable trees.

Cut-surface treatments are more effective than basal-bark treatments on plants that are greater than 5 inches in diameter or on thick-barked species. The herbicide is applied to the stump of a cut plant or to frills or notches cut around the plant to a depth of at least 1/2 inch into the sapwood. Special injection equipment can be used to cut the plant and apply the herbicide in one operation. The herbicide should be applied to the cut surface before the exposed plant tissue dries, which is usually within 2 or 3 hours after cutting. When treating cut stumps, thoroughly drench the plant so that the runoff covers crown buds and all exposed roots. Most herbicides used for cut-surface treatments volatilize readily. Treatment can be made during the dormant season when the potential for drift injury is low or during any other time of the year.

Soil treatments can be made using certain herbicides that move through the soil to the root zone and then translocate upward to kill the plant. Treatments are applied as sprays within the drip line of the target species or dry as granules or pellets. Exercise care in applying these herbicides to minimize damage to nearby desirable species. Damage can result if there is lateral herbicide movement or if you treat areas where the root zones of desirable and target species overlap.

Most soil treatments can be made throughout the year. They should not be applied to frozen ground. The soil-applied herbicides usually remain active in the soil for several months. For that reason you should not use them where there is a possibility that they might run off into water sources or cropping areas or where they might leach into ground water.

Brush Herbicides

Phenoxy herbicides used for brush control are 2,4-D, dichlorprop (2,4-DP), 2,4,5-T, and silvex (2,4,5-TP). 2,4-D is labeled for brush control in pastures, drainage-ditch banks, right-of-ways, and noncrop areas. Dichlorprop is labeled for use on right-of-ways and noncrop areas (Table 1). Silvex and 2,4,5-T are currently under emergency suspension and are undergoing review by the U.S. Environmental Protection Agency (EPA). Its final decision may change the status of these two compounds. At present they *cannot* be used in pastures, right-of-ways (which include roadsides, railroads, pipelines, power lines, and utilities), on drainage-ditch banks, or around waterways or homes. They can, however, be used for brush control on rangeland and on such noncroplands as industrial, storage, and waste areas as long as those areas are not specifically mentioned in the above list of area restrictions. According to the U.S. EPA, pasture is distinguished from rangeland by the use of an annual improvement treatment such as fertilization, mowing, insect control, or weed control. The use of either silvex or 2,4,5-T on fencerows or hedgerows is legal if the fence or hedge does not border a suspended area.

Silvex and 2,4,5-T control a broader spectrum of brush species than 2,4-D or dichlorprop although certain species are adequately controlled by 2,4-D or dichlorprop.

Other herbicides are sometimes combined with 2,4-D to broaden the spectrum of susceptible plants. Tables 2, 3, 4, and 5 indicate the susceptibility of common brush species to certain herbicide treatments. Much of the information in these tables was taken from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook No. 493, U.S. Department of Agriculture.

The phenoxy herbicides are readily absorbed by plant foliage. Oil-soluble formulations (esters or oil-soluble amines) applied in kerosene or diesel oil will penetrate the bark of most woody plants. The esters are usually more effective than the amines when treating brush and trees with foliar or basal-bark sprays. Amines are preferable for injection and cut-surface treatments.

Minute quantities of phenoxy herbicides may cause injury to highly susceptible nontarget plants such as tomatoes, grapes, cotton, tobacco, cucumber, and ornamentals whether the method of application is foliar, basal bark, or cut surface. (Foliar treatment may result in greater injury than that caused by the other methods because it requires a greater volume of herbicide.) The vapor from a phenoxy treatment may travel up to 1/2 mile. To reduce vapor drift, use amine rather than ester formulations when possible. If you must use an ester, choose a low-volatile (L.V.) rather than high-volatile (H.V.) formulation. Do not use an ester when the temperature on the day of treatment exceeds 85° F. Do not treat near highly sensitive nontarget plants. Do not apply phenoxys to water intended for domestic use or irrigation.

If possible, do not use phenoxy spray equipment to apply other pesticides to phenoxy-susceptible plants. Some residue may remain even after thorough cleaning. Follow all use restrictions listed on the herbicide label.

Banvel (dicamba) is a translocated selective herbicide that can be absorbed through the roots or the above-ground portions of plants. Banvel is used for foliar, cut-surface, basal-bark, or soil treatments. Foliar sprays can be applied with ground or aerial equipment. The granular or pellet formulations that are available for soil treatments should be applied in spring or early summer. The spectrum of species controlled with Banvel can be broadened by the addition of 2,4-D as recommended on the label.

Banvel is effective in small amounts. Like the phenoxys, it volatilizes readily. Take precautions to prevent drift to sensitive feed and food crops, ornamentals, and conifers. The label tells how long to delay grazing and harvesting after treatment with Banvel and restricts the use of Banvel near soybeans in certain stages of growth. Study the label carefully before applying.

Tordon (picloram) is a translocated selective herbicide that is absorbed by the roots and foliage of plants. Formulations are available for foliar, soil, or cut-surface applications. Liquid formulations may be oil based for foliar treatments or water soluble for cut-surface applications. Mixtures with phenoxy herbicides are available to give broader spectrum weed control.

Soil treatments may be applied as liquids or dry in pellet form. Rainfall is required to wash the dry formulation into the root zone. Broadcast soil treatments are recommended for dense brush. Spot treatments can be made to individual plants or scattered stands of brush.

Table 2. Foliar Herbicide Treatment, Susceptibility of Common Brush Species[a]

	Foliar spray												
	2,4-D	2,4,5-T	2,4-D + 2,4,5-T	Silvex	Dichlorprop	Banvel	Tordon	Hyvar	Garlon	Ammate	Amitrole	Roundup	Krenite
Ash, white (*Fraxinus americana*)	R	I-R	I-R	I-R	R	S-R	S-R	S-R	S-I	S-I	S	S-I	I
Birch (*Betula* spp.)	S-I	S-I	S-I	S	S	S	S	S	S-I	S	..	S	S
Boxelder (*Acer negundo*)	S-I	S-I	S-I	I-R	I-R	..	S-I	S	..	..	..	S	..
Brambles—blackberry, raspberry, etc. (*Rubus* spp.)	I-R	S-I	..	S-I	I-R	S-I	S-I	S-I	S-I	I-R	S-I	S-I	S
Cedar, eastern red (*Juniperus virginiana*)	R	R	R	R	R	I-R	S-I	S	..	I	..	S	..
Cherry, black, and choke (*Prunus serotina* and *P. virginiana*)	I-R	S-I	I	I	I-R	S	S-I	S-I	S-I	S	S	S	I
Cottonwood, eastern (*Populus deltoides*)	S-R	S-R	S	R	R	R	..	S-I	S-I	S	..	..	S-I
Crabapple (*Pyrus ioensis*)	S-I	S	..	S	S	S	S	S	..	S	..	S	..
Elderberry (*Sambucus canadensis*)	S-I	S-I	R	S-I	I	S	S	S	S-I	R	..	S	..
Elms, American and slippery (*Ulmus* spp.)	I	I	I	I	S-I	I	S-I	S-I	S-I	S-I	..	S	S-I
Grapes, wild (*Vitis* spp.)	S-I	S-I	..	S-I	S-I	I-R	S-I	..	..	S-I	..	S	S-I
Greenbrier or catsbriar (*Smilax* spp.)	R	I-R	I	R	R	R	I-R	R	..	I-R	..	..	..
Hackberry (*Celtis* spp.)	I-R	S-I	I	S-I	I-R	I	S-I	S-I	..	I	..	S	..
Hawthorn (*Crataegus* spp.)	I-R	R	I-R	R	R	R	S-I	..	S-I	I	..	S	I
Hedge-apple or osage orange (*Maclura pomifera*)	I-R	S	S	R	R	I-R	..	..	..	R	..	..	..
Honeylocust (*Gleditsia triacanthos*)	I-R	S	I	I	I	S-I	S	S	S-I	S-I	..	S	..
Honeysuckle (*Lonicera* spp.)	S-I	S-I	..	S-I	S-I	I	S-I	S	..	I	S-I	S	..
Locust, black (*Robinia pseudoacacia*)	S-I	S-I	S	S-I	S-I	S	S-I	S	S-I	I	S	S	S
Mulberry, red (*Morus rubra*)	I-R	I	I	I-R	I-R	S-I	S-I	..	S-I	I-R	..	..	..
Persimmon, eastern (*Diospyros virginiana*)	I	I	..	I-R	I-R	S-I	S-I	..	S-I	I	..	..	I
Plum, wild (*Prunus* spp.)	S-I	I	I-R	I	I	S-I	S	..	..	I	..	S	S-I
Poison ivy (*Rhus radicans*)	I	S	S	S-I	I	S	S	S	..	S	S	S	..
Rose, multiflora (*Rosa multiflora*)	..	S	S	..	..	..	S	..	..	..	..	S	S-I
Sassafras (*Sassafras albidum*)	S-I	S-I	I	I	I	I	S-I	S	S-I	S-I	..	S	I
Sumac (*Rhus* spp.)	S	S	S	S	S	S	S	S-I	S-I	S-I	S	S	S
Tree-of-heaven (*Ailanthus altissima*)	S-I	S-I	S	I	S-I	S-I	S-I	S	..	I	..	S	S-I
Trumpet-creeper (*Campsis radicans*)	..	..	..	..	..	S-I	..	..	..	..	..	S-I	..
Virginia creeper (*Parthenocissus quinquefolia*)	S	S	..	..	S-I	..	..	..	..	R	..	S	..
Willow (*Salix* spp.)	S	S-I	S	S-I	S	S-I	S-I	S	S-I	S-I	..	S	I

[a]S = Susceptible, I = Intermediate, R = Resistant, S-I = Susceptible to Intermediate, S-R = Susceptible to Resistant, I-R = Intermediate to Resistant. Table is adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agricultural Handbook No. 493, U.S. Department of Agriculture.

Table 3. Basal-Bark Herbicide Treatments, Susceptibility of Common Brush Species[a]

	Basal-bark spray								
	2,4-D	2,4,5-T	Silvex	Dichlorprop	Banvel	Tordon	Hyvar	Ammate	Garlon
Ash, white *(Fraxinus americana)*	R	I	R	R	S-I	S-I	S	S	S
Birch (*Betula* spp.)	S	S	..	..	..	S-I	S	S	S
Boxelder *(Acer negundo)*	S	S	S	S	S	S	S	S-I	..
Brambles—blackberry, raspberry, etc. (*Rubus* spp.)	I-R	S-I	S-I	S-R	S	S	S	I-R	S
Cedar, eastern red *(Juniperus virginiana)*	R	I-R	R	R	S-I	S	S	S	..
Cherry black, and choke *(Prunus serotina* and *P. virginiana)*	S-R	S	S	S	S	S	S-I	S	S
Cottonwood, eastern *(Populus deltoides)*	..	..	..	..	..	..	S	..	S
Crabapple *(Pyrus ioensis)*	S-I	S	S-I	S-I	S	S	S-I	S	..
Elderberry *(Sambucus canadensis)*	S-I	R	..	S	S	S	S	I	S
Elms, American and slippery (*Ulmus* spp.)	S-I	S	R	S-I	S	S	S-I	S-I	S
Grapes, wild (*Vitis* spp.)	..	..	..	..	..	..	..	I	..
Greenbrier or catsbriar (*Smilax* spp.)	I	I	I	..	R	I-R	R	R	..
Hackberry (*Celtis* spp.)	S	S	S	S	..	S-I	S	S	..
Hawthorn (*Crataegus* spp.)	I	I	S-R	S-R	S-R	S	S	I	..
Hedge-apple or osage orange (*Maclura pomifera)*	I	S	R	R	..	S	I	I	..
Honeylocust *(Gleditsia triacanthos)*	I	S	..	I	..	S-I	S	S-I	..
Honeysuckle *(Lonicera* spp.)	S	S	S	S	S	S	I-R	R	..
Locust, black *(Robinia pseudoacacia)*	I	I	I	I-R	S-I	S-I	S	I-R	S
Mulberry, red *(Morus rubra)*	I-R	I	I-R	I-R	S	S	I	I	S
Persimmon, eastern *(Diospyros virginiana)*	I-R	I	I	R	S	S	I	S-I	S
Plum, wild (*Prunus* spp.)	S-I	S	S	S-I	S	S	S	S	..
Poison ivy *(Rhus radicans)*	I	S	..	..	..	..	S	S	..
Rose, multiflora *(Rosa multiflora)*	..	..	..	..	..	..	..	..	..
Sassafras *(Sassafras albidum)*	S-I	S-I	S	S-R	S	S	I	S-I	S
Sumac *(Rhus* spp.*)*	R	S	S-I	R	S	S	S	R	S
Tree-of-heaven *(Ailanthus altissima)*	S-R	S	..	S-I	S	S	S	I	..
Trumpet-creeper *(Campsis radicans)*	..	..	..	..	..	..	..	..	..
Virginia creeper *(Parthenocissus quinquefolia)*	..	..	S	..	..	..	R	R	..
Willow (*Salix* spp.)	S	S	S	S	..	S-I	S	S	S

[a]S = Susceptible, I = Intermediate, R = Resistant, S-I = Susceptible to Intermediate, S-R = Susceptible to Resistant, I-R = Intermediate to Resistant. Table is adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agriculture Handbook No. 493, U.S. Department of Agriculture.

Table 4. Injection/Cut Surface Treatment, Susceptibility of Common Brush Species[a]

	2,4-D	2,4,5-T	Silvex	Dichlorprop	Garlon	Banvel	Tordon + 2,4-D	Ammate
Ash, white (*Fraxinus americana*)	I	..	..	..	S	S	..	S-I
Birch (*Betula* spp.)	..	..	..	S-I	S	S	S-I	S-I
Boxelder (*Acer negundo*)	..	..	..	..	..	..	..	..
Brambles—blackberry, raspberry, etc. (*Rubus* spp.)	..	..	S-I	S-I	S	..	..	..
Cedar, eastern red (*Juniperus virginiana*)	R	R	..	..	..	S-I	..	..
Cherry, black and choke (*Prunus serotina* and *P. virginiana*)	..	..	..	S-I	S	..	S-I	..
Cottonwood, eastern (*Populus deltoides*)	S-I	S-I	..	..	S	..	..	..
Crabapple (*Pyrus ioensis*)	..	..	..	..	..	..	..	..
Elderberry (*Sambucus canadensis*)	..	..	..	..	S	..	..	..
Elms, American and slippery (*Ulmus* spp.)	S-I	S	..	..	S	..	S-I	..
Grapes, wild (*Vitis* spp.)	S	S	..	..	..	..	..	..
Greenbrier or catsbriar (*Smilax* spp.)	..	..	..	..	..	..	..	..
Hackberry (*Celtis* spp.)	S	S	..	..	..	..	..	..
Hawthorn (*Crataegus* spp.)	R	R	..	..	..	..	S-I	..
Hedge-apple or osage orange (*Maclura pomifera*)	S-I	S	..	..	..	..	..	..
Honeylocust (*Gleditsia triacanthos*)	..	..	..	..	..	..	..	..
Honeysuckle (*Lonicera* spp.)	..	..	S-I	S-I	..	..	..	..
Locust, black (*Robinia pseudoacacia*)	S	S	S-I	S-I	S	..	..	..
Mulberry, red (*Morus rubra*)	..	..	..	..	S	..	..	..
Persimmon, eastern (*Diospyros virginiana*)	I	I-R	S-I	..	S	S	S-I	..
Plum, wild (*Prunus* spp.)	..	..	..	..	..	..	..	..
Poison ivy (*Rhus radicans*)	..	..	S-I	S-I	..	..	..	..
Rose, multiflora (*Rosa multiflora*)	..	..	..	..	..	..	..	..
Sassafras (*Sassafras albidum*)	..	..	..	..	S	..	..	..
Sumac (*Rhus* spp.)	..	..	..	..	S	..	..	..
Tree-of-heaven (*Ailanthus altissima*)	..	..	..	..	..	..	..	..
Trumpet-creeper (*Campsis radicans*)	..	..	..	..	..	..	..	..
Virginia creeper (*Parthenocissus quinquefolia*)	..	..	..	..	..	..	..	..
Willow (*Salix* spp.)	S	S	S-I	S-I	S	..	..	S-I

[a]S = Susceptible, I = Intermediate, R = Resistant, S-I = Susceptible to Intermediate, S-R = Susceptible to Resistant, I-R = Intermediate to Resistant. Table is adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agricultural Handbook No. 493, U.S. Department of Agriculture.

Table 5. *Soil Herbicide Treatment, Susceptibility of Common Brush Species*[a]

	Banvel	Tordon	Hyvar	Velpar	Spike
Ash, white (*Fraxinus americana*)	..	I	S	..	S
Birch (*Betula* spp.)	..	..	S	..	..
Boxelder (*Acer negundo*)	..	..	S	..	S
Brambles—blackberry, raspberry, etc. (*Rubus* spp.)	..	S-I	S	..	S
Cedar, eastern red (*Juniperus virginiana*)	S-I	S-I	S	..	S
Cherry, black and choke (*Prunus serotina* and *P. virginiana*)	..	S	S-I	..	S
Cottonwood, eastern (*Populus deltoides*)	..	..	..	..	S
Crabapple (*Pyrus ioensis*)	..	..	I	..	..
Elderberry (*Sambucus canadensis*)	..	S-I	S	..	..
Elms, American and slippery (*Ulmus* spp.)	S-I	S	S	..	S
Grapes, wild (*Vitis* spp.)	..	S-I	..	..	..
Greenbrier or catsbriar (*Smilax* spp.)	R	R	R	..	S
Hackberry (*Celtis* spp.)	..	S	S	..	S
Hawthorn (*Crataegus* spp.)	R	S	S-R	S-I	S
Hedge-apple or osage orange (*Maclura pomifera*)	..	..	R	..	..
Honeylocust (*Gleditsia triacanthos*)	..	S-I	S	..	..
Honeysuckle (*Lonicera* spp.)	..	..	I-R	..	..
Locust, black (*Robinia pseudoacacia*)	..	S-I	S	..	S
Mulberry, red (*Morus rubra*)	..	S-I	I	..	S
Persimmon, eastern (*Diospyros virginiana*)	S	S	I	..	S
Plum, wild (*Prunus* spp.)	..	..	S	..	S
Poison ivy (*Rhus radicans*)	..	..	S	..	..
Rose, multiflora (*Rosa multiflora*)	..	S-I	..	..	S
Sassafras (*Sassafras albidum*)	..	S-I	I	..	..
Sumac (*Rhus* spp.)	..	S	S	S-I	S
Tree-of-heaven (*Ailanthus altissima*)	..	..	S	..	S
Trumpet-creeper (*Campsis radicans*)	..	..	..	S-I	S
Virginia creeper (*Parthenocissus quinquefolia*)	..	..	R	..	S
Willow (*Salix* spp.)	..	..	S	S-I	S

[a]S = Susceptible, I = Intermediate, R = Resistant, S-I = Susceptible to Intermediate, S-R = Susceptible to Resistant, I-R = Intermediate to Resistant. Table is adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agricultural Handbook No. 493, U.S. Department of Agriculture.

Picloram moves easily in the soil water and remains active for a long time. A low concentration can cause extensive damage to susceptible species. Avoid applying where runoff or ground water could move the herbicide into the root zone of susceptible nontarget plants such as conifers, or broadleaf ornamentals and crops. Prevent picloram from drifting into water containments and areas where desirable plants are growing. Vapor drift to nontarget species is less injurious if treatment is made during the dormant season.

Tordon is a restricted-use herbicide that can be applied only by certified private or commercial applicators.

Garlon (triclopyr) is a systemic selective herbicide that can be applied as a foliar, basal-bark, or cut-surface treatment. Compared to many brush herbicides, Garlon gives superior control of ash, oak, and certain root-sprouting species. Commercial mixes of triclopyr plus 2,4-D or picloram are available to control a broader spectrum of brush species.

Take measures to prevent drift of Garlon formulations to susceptible ornamentals, crops, and conifers.

Trimec 352 is a commercial mixture of 2,4-D, mecoprop, and dicamba designed for foliar applications to give broad-spectrum brush control. A low concentration can damage susceptible species. Take precautions to prevent drift injury.

Ammate X (AMS) is a nonselective herbicide that can be used as a foliar spray or in a cut-surface treatment for brush control. A large concentration and thorough coverage are required to kill plants. A surfactant will aid control.

Since AMS is not volatile, drift should not be a problem, but you should avoid spraying desired plants directly. In pasture or rangeland, spray away from forage plants to avoid suppressing or killing them. The formulation Ammate X-NI can be used on land adjacent to streams and public water supply areas.

Ammate X is corrosive to spray equipment. Clean equipment immediately after use and coat with diesel oil.

Krenite (fosamine) is a contact herbicide that is applied to the foliage of brush during the two-month period prior to fall coloration. No effects are seen until the following spring when treated plants fail to refoliate and subsequently die. Pine species may respond during the season of treatment. Thorough coverage is required for complete control. By carefully directing the application, you can use Krenite to trim woody species without killing the entire plant. A surfactant can be used to improve control.

Krenite should not be applied to desirable plants, brush standing in water, or food crops. Krenite can be slightly corrosive to brass or copper spray equipment. Clean thoroughly after each use to protect the sprayer.

Amitrole is a nonselective translocated herbicide that is especially effective against poison ivy, poison oak, brambles, and honeysuckle. Amitrole can be used only where there is no possibility that residues will remain on food or feed crops (See Table 1). Amitrole is available as a water soluble powder as Amizol and Amino Triazole. It is available with ammonium thiocyanate under the trade names of Amitrol-T and Cytrol Amitrole-T. Amitrole is applied in foliar sprays. All leaves, stems, and suckers should be thoroughly wet to the ground line. The addition of a surfactant might improve control.

Because amitrole gives nonselective control, it should be directed where loss of ground cover would be detrimental. Keep amitrole out of aquatic areas if the water is intended for irrigation, drinking, fishing, or other domestic purposes. Keep livestock off treated areas.

Roundup (glyphosate) is a nonselective systemic herbicide that can be used for spot treatments in areas where loss of ground cover is detrimental. Because plants absorb the herbicide through their foliage, application must be made during the season of active growth. Flowering species should be treated when the plants are at or beyond the full-bloom stage of growth. Roundup has no soil activity. Prevent drift to foliage of nontarget species.

Hyvar-X (bromacil) is a nonselective foliage or soil-applied herbicide that is used for the control of a wide spectrum of woody species. Depending upon the formulation, bromacil can be applied dry or in a water spray. Rainfall or irrigation leaches the herbicide into the root zone. Hyvar-X may be broadcast above the roots of plants just before or during active growth. Spot treatments around the base of woody plants may be appropriate in areas where bare ground is undesirable. Treated plants may not respond until some time after application.

Do not apply Hyvar-X to frozen ground or to brush that is standing in water. Since the undiluted product is combustible, keep it away from heat and open flame. Thoroughly clean all traces of Hyvar-X from spray equipment immediately after use. Do not use aluminum spray nozzles.

Velpar (hexazinone) is a nonselective herbicide that is taken up by the roots and foliage of plants. Velpar is most effective when applied to the soil just before or soon after weed emergence. Velpar also has some contact activity if an appropriate surfactant is added to the spray mix. The recommended rate varies with soil type. Higher rates are recommended when treating hard-to-control species. Velpar gridballs are labeled for some uses.

Avoid application of Velpar to the root zone or foliage of desirable plants. Spot treatment is necessary when bare soil is undesirable. Exceeding the concentration recommended on the label might clog nozzles and result in uneven distribution. Agitate the herbicide mixture for at least ten minutes until Velpar is thoroughly dissolved.

Spike (tebuthiuron) is a soil-applied nonselective herbicide. To achieve the best results, apply the herbicide prior to or during active growth of target plants. Spike can be applied to the soil dry or with a water carrier. The dry application requires rainfall to wash the herbicide into the root zone.

The wettable powder formulation requires continuous agitation. Spike does not leach readily in the soil. Avoid application where runoff can wash the dry herbicide into nontarget areas. Take measures to prevent drift or direct application of Spike to the root zone of desirable plants.

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Chemical Control of Some Aquatic Plants

R.C. Hiltibran

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
EMERSED PLANTS			
Arrowhead (*Sagittaria* spp.)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	amine (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	diquat cation (2 lb./gal.)	1/4 cup/gal.	Wet foliage
Bulrush (*Scripus acutus* Muhl.)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/2 cup/2 gal.	Wet stems
	diquat cation (2 lb./gal.)	2 tbsp./3 gal. and 1 tsp. non-ionic wetting agent	Wet foliage to point of run-off
	dichlobenil (aquatic granules 10%)	40 lb./A.	Apply in March to exposed bottom soil
Cattails (*Typha* spp.)	Use one of the following:		
	dalapon	4 oz./gal. and 3 caps detergent	Wet foliage
	amitrole	2 oz./gal. and 3 caps detergent	Wet foliage
	2,4-D ester (4 lb./gal.)	1/2 cup/gal. and 3 caps detergent	Wet foliage
	diquat cation (2 lb./gal.)	2 tbsp./3 gal. and 1 tsp. nonionic wetting agent	
Creeping water primrose (*Jussiaea repens* L. var. *glabrescens* Ktze.)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	amine (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	diquat cation (2 lb./gal.)	1/4 cup/2 gal.	Wet foliage
Spatterdock (*Nuphar advena* (Ait.) Ait. f.)	dichlobenil (aquatic granules 10%)	60 lb./A.	Spread on water

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
Waterwillow (*Justicia americana* (L.) Vahl)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	amine (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	diquat cation (2 lb./gal.)	1/4 cup/2 gal.	Wet foliage
SUBMERSED PLANTS WITH ALTERNATE LEAF ATTACHMENT			
Curlyleaf pondweed (*Potamogeton crispus* L.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below surface
	diquat cation (2 lb./gal.)	0.5 ppm or 1 gal./surface A.	Same as above
	dichlobenil (aquatic granules 10%)	80 lb./A.	Preemergent application
	fenac	See manufacturer's directions	Must be applied to exposed pond bottom
	diquat cation copper-triethanolamine complex	0.25 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Leafy pondweed (*P. foliosos* Raf.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below water surface
	diquat cation (2 lb./gal.)	0.5 ppm, or 1 gal./surface A.	Same as above
	dichlobenil (aquatic granules 10%)	120 lb./A.	Preemergent application*
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Sago pondweed (*P. pectinatus* L.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below water surface

*The preemergent herbicides have not given satisfactory season-long control of leafy pondweed.

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
Sago pondweed (continued)	diquat cation (2 lb./gal.)	0.5 ppm, or 1 gal./ surface A.	Same as endothall
	dichlobenil (aquatic granules 10%)	40 lb./A.	Preemergent application
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Small pondweed (*P. pusillus* L.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below water surface
	diquat cation (2 lb./gal.)	0.5 ppm	Same as above
	dichlobenil (aquatic granules 10%)	80 lb./A.	Preemergent application
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Waterstargrass (*Heteranthera dubia* (Jacq.) MacM.)	Use one of the following:		
	diquat cation (2 lb./gal.)	1 ppm, or 2 gal./ surface A.	Apply on or below water surface
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	5 ppm	Same as above
SUBMERSED AQUATIC PLANTS WITH OPPOSITE LEAF ATTACHMENT			
White buttercup (*Ranunculus trichophyllus* Chaix)	diquat cation (2 lb./gal.)	0.5 ppm	Apply below water surface
Slender naiad (*Najas flexilis* (Willd.) Rostk. & Schmidt)	Use one of the following:		
	copper-ethylene-diamine complex*	0.5-1.0 ppm (copper)	Apply below water surface
	diquat cation (2 lb./gal.)	1 ppm, or 1.5 gal./ surface A.	Same as above
	diquat cation/copper-triethanolamine complex	0.5 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	3 ppm (total or large-scale application) 4 ppm (marginal application)	Same as above

*Sold under the trade name of Komeen by the Sandoz Corporation.

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
Slender naiad (continued)	dichlobenil (aquatic granules 10%)	80 lb./A.	Preemergent application
Southern naiad (*N. guadalupensis* (Spreng.) Magnus)	Use one of the following:		
	copper-ethylenediamine complex*	0.5-1.0 ppm (copper)	Apply below water surface
	diquat cation (2 lb./gal.)	1 ppm, or 1.5 gal./surface A.	Apply below water surface
	diquat cation/copper-triethanolamine complex	0.5 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	3 ppm (total or large-scale application) 4 ppm (marginal application)	Same as above
	dichlobenil (aquatic granules 10%)	80 lb./A.	Preemergent application
SUBMERSED AQUATIC PLANTS WITH WHORLED LEAF ATTACHMENT			
Common coontail (*Ceratophyllum demersum* L.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	2 ppm	Spread on water
	2,4-D ester (20% G)	2 ppm	Spread on water
	diquat cation (2 lb./gal.)	1 ppm, or 2 gal./surface A.	Apply below water surface
	diquat cation/copper-triethanolamine complex	0.5 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
Elodea (*Elodea canadensis* Michx.)	Use one of the following:		
	copper-ethylenediamine complex*	0.5-1.0 ppm (copper)	Apply below water surface
	diquat cation (2 lb./gal.)	1 ppm, or 2 gal./surface A.	Apply below water surface
	diquat cation/copper-triethanolamine complex	0.5 ppm diquat cation plus an equal volume of copper-triethanolamine complex	Apply on or below water surface
Watermilfoil (*Myriophyllum* spp.)	Use one of the following:		
	2,4-D ester (20% G)	2 ppm	Spread on water
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	3 ppm 3 ppm of 10% G	Apply below water surface Spread on water
	diquat cation (2 lb./gal.)	1 ppm	Apply below water surface

*Sold under the trade name of Komeen by the Sandoz Corporation.

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
Watermilfoil (continued)	dichlobenil (aquatic granules 10%)	100-150 lb./A.	Spread on water
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
FLOATING-LEAVED AQUATIC PLANTS			
American pondweed (*Potamogeton nodosus* Poir.)	Use one of the following:		
	endothall (10% G)	1 ppm	Spread on water
	endothall (potassium salt, 4.23 lb./gal.)	1/2 cup/gal.	Apply to leaves
Waterlilies (*Nymphaea* spp.)	dichlobenil (aquatic granules 10%)	50 lb./A.	Spread on water
	2,4-D (20% G)	200 lb./A.	
FREE-FLOATING AQUATIC PLANTS			
Common duckweed (*Lemna minor* L.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal.)	1 cup/4 gal.	Apply to leaves
	diquat cation (2 lb./gal.)	1 cup/4 gal.	Apply to leaves
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Watermeal (*Wolffia columbiana* Karst.)	simazine (80-WP)	1 ppm	Apply to total water volume
ALGAE			
Chara (has cylindrical, whorled branches and resembles, in form, some of the plants mentioned above) (*Chara* spp.)	Use one of the following:		
	dichlobenil (aquatic granules 10%)	40 lb./A.	Preemergent application only
	copper sulfate*	1 ppm	Postemergent application
	Aquatic Herbicide System M**	15-25 lb./A.	Apply on water surface
Filamentous algae	copper sulfate*	1 ppm	Postemergent
	Aquatic Herbicide System M**	15 lb./A.	Spread on water
	simazine (80-WP)	0.5 ppm	Apply to total water volume

*Crystalline copper sulfate can be used; however, there are several copper-containing formulations that contain copper-chelating compounds, which prevent the immediate precipitation of copper as copper carbonate. Check the label for instructions concerning their uses and rates of application. A lower rate of application for copper can be used with these latter formulations. Their copper contents may vary.

**A copper-containing formulation developed by the 3M Company and distributed under the trade name of Mariner.

ADDITIONAL INFORMATION

Aquatic Plants and their Control. Fishery Bulletin No. 4, Illinois Department of Conservation, Springfield, IL 61706.

The Toxicity of Herbicides

Toxicity is the capacity of a substance to produce injury, and the toxic action of greatest concern is the lethal dosage (LD). This action can be immediate (acute) or it can be accumulative (chronic). Results of tests with animals show that the toxicity of a given substance varies with the animal's species, age, sex, and nutritional status and also with the route of administration (internal--stomach, lungs; or external--dermal).

Before companies are granted clearances on their compounds, they are required to perform several types of toxological tests with them. They conduct mutagenic and teratogenic tests by progeny and litter testing. They also conduct acute, subacute, and chronic toxicity tests. One of the most useful expressions for acute lethal toxicity is the LD_{50}, which represents the average lethal dosage per unit of body weight required to kill one-half (50 percent) of a test population.

Toxicity must, of necessity, be tested on animals rather than people. The usual test animals are white rats, but mice, rabbits, and dogs are sometimes used. The most common LD_{50} expression represents the acute oral toxicity, that is, the single internal dosage necessary to kill one-half of the test animals. The acute oral toxicity has limitations, however, because it represents only the immediate toxicity of an internal dosage and not the chronic, accumulative effects of any skin absorption or irritation. Few herbicides are absorbed rapidly through the skin, and most herbicides do not accumulate in the body to a toxic level, although some do cause skin irritation.

LD_{50} values are expressed in terms of milligram of chemical per kilogram of body weight (mg/kg). Some conversion factors to convert common terms are as follows:

1 ounce = 28.38 grams = 28,380 milligrams
1 kilogram = 1,000 grams = 2.2 pounds
mg/kg x 0.0016 = ounces/hundredweight or $\frac{\text{mg/kg}}{625}$ = ounces/hundredweight
mg/kg x 0.0030 = ounces/180 pounds

Therefore an LD_{50} of 1,000 mg/kg would be 3 ounces of material per 180 pounds of body weight, whereas LD_{50} values of 100 and 10 would be 0.30 and 0.03 ounce per 180 pounds, respectively. Because toxicities depend on body weight, it would take only one-third of that amount to be lethal to a 60-pound child and five times as much to kill a 900-pound animal.

The LD_{50} values are expressed on the basis of active ingredient. If a commercial material is only 50 percent active ingredient, it would take two parts of the material to make one part of the active ingredient. In some cases, chemicals mixed with the active ingredient (adjuvants) for formulating a pesticide may cause the toxicity to differ from that of the active ingredient alone. For example, the LD_{50} of 2,4-D acid is 320 mg/kg, whereas those of the ester formulations are 500 to 600.

W-24

The persistence of herbicides is an important factor in herbicide toxicity. A relatively toxic material that is not easily broken down is potentially more hazardous than one that decomposes rapidly after application. Soil persistence of herbicides is discussed in Agronomy Facts No. W-22a.

Pesticides must be carefully handled and stored only in properly labeled original containers. They should be kept where children cannot reach them. Empty containers should be destroyed or disposed of where children and animals cannot find them. Even though the LD_{50} of some herbicides may indicate a relatively low toxicity, it is good to form the habit of handling *all* pesticides carefully.

Proper precautions should be taken where livestock graze or are fed crops from treated areas. Although a certain herbicide may not be very toxic to animals, some residue may occur in the meat or milk. Treated pastures should not be grazed by dairy animals for 7 days after they have been treated with 2,4-D. Questions associated with 2,4-D toxicity in forage or food crops are discussed in Agronomy Facts No. W-23.

The acute oral LD_{50} values for the active ingredient of some common herbicides are given in Agronomy Facts No. W-38, *Herbicides, Formulations, and Toxicities*. Remember: *The lower the LD_{50} value, the greater the toxicity.* A common standard for comparison is aspirin, which has an LD_{50} of 1,200 mg/kg; the LD_{50} for table salt is 3,320.

The toxicity ratings for the various LD_{50} values are as follows:

Rating	*LD_{50}*	*Probable lethal dose for man*
Highly toxic	1-50	A few drops to 1 teaspoon
Moderately toxic	50-500	1 teaspoon to 2 tablespoons
Slightly toxic	500-5,000	1 ounce to 1 pint
Practically nontoxic	5,000-15,000	1 pint to 1 quart
Relatively harmless	15,000+	1 quart +

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Herbicides, Formulations, and Toxicities

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute oral LD_{50}[e]	Acute dermal LD_{50}[f]
acifluorfen		2 lb./gal. S	Moderate	3,330	>5,000
(Rohm & Haas)	Blazer				
(Rhone-Poulenc)	Tackle				
alachlor		4 lb./gal. EC,	Severe	1,800	5,000
(Monsanto)	Lasso	15% G			
ametryn		80% WP	Moderate	1,110	>1,020
(CIBA-Geigy)	Evik				
amitrole		90% WSP,	Mild	24,600	
(American Cyanamid)	Amino-Triazole	50% WSP			
(Union Carbide)	Weedazol				
amitrole-T		2 lb./gal. S,	Mild	5,000	
(Union Carbide)	Amitrol-T	2 lb./gal. S			
(American Cyanamid)	Cytrol				
AMS		95% WSP	Mild	3,900	
(DuPont)	Ammate-X				
asulam		3.34 lb./gal. S	Mild	>8,000	>1,000
(Rhone-Poulenc)	Asulox				
atrazine		8% G,	Mild	3,080	9,300
(CIBA-Geigy)	AAtrex	80% WP,			
(many)	atrazine	4 lb./gal. WDL,			
		90% WDG			
atrazine + metolachlor		2 + 2.5 lb./gal. WDL		4,680	
(CIBA-Geigy)	Bicep				
atrazine and propachlor		48.1% + 20.9% WP,			
(Monsanto)	Ramrod/atrazine	3 + 1 lb./gal. WDL			
benefin		1.5 lb./gal. EC,	Moderate	5,000	
(Elanco)	Balan	2.5% G			
bensulide		4 lb./gal. EC,	Mild	770	>4,640
(Stauffer)	Betasan	3.6,7, & 12.5% G			
	Prefar				
bentazon		4 lb./gal. S	Moderate	1,100	>2,450
(BASF)	Basagran				
bifenox		4 lb./gal. WDL,	Moderate	1,630	>20,000
(Rhone-Poulenc)	Modown	80% WP			
boron compounds	(several)	(various)	Moderate	2,000	

[a]Weed-Science-Society-of-America-approved name, or experimental number.
[b]"Several" indicates many trade names.
[c]EC means emulsifiable concentrate; G, granules; L, liquid; S, water solution; WDG, water-dispersible granule; WDL, water-dispersible liquid; WP, wettable powder; WSP, water-soluble powder; DF, dry flowable; P, pellet; F, flowable.
[d]Dermal irritation is determined by applying an amount of pesticide onto the skin of shaved test animals. A blank indicates that the information is not available at this time.
[e]LD_{50} means the milligrams of chemical per kilogram of body weight that are lethal to 50 percent of the test animals, usually white rats, when administered in a single, *oral* dose.
[f]LD_{50} means the milligrams of chemical per kilogram of body weight that are lethal to 50 percent of the test animals, usually rabbits, when administered in a single, *dermal* dose. A blank indicates that the information is not available at this time.

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute oral LD_{50}[e]	Acute dermal LD_{50}[f]
bromacil (DuPont)	Hyvar-X	2 lb./gal. EC, 80% WP, 10% G	Moderate	5,200	>5,000
bromoxynil (Rhone-Poulenc) (Union Carbide)	Buctril Brominal	2 lb./gal. EC	Moderate	260 to 440	>3,660
butylate (Stauffer)	Sutan+	6.7 lb./gal. EC, 10% G	Moderate	3,690	>4,640
cacodylic acid (several)	(several)	3.25, 2.48, & 5.7 lb./gal. L, 65% WSP	Mild	830	
chloramben (Union Carbide)	Amiben Vegiben	2 lb./gal. S, 10% G	Moderate	3,500	>774
chlorpropham (PPG Industries)	Chloro IPC Furloe	4 lb./gal. EC, 10 & 20% G	Mild	3,700	10,200
copper sulfate	(several)	(various)	Mild	470	>8,000
cyanazine (Shell)	Bladex	80% WP, 15% G, 4 lb./gal. WDL	Mild	334	>2,000
cycloate (Stauffer)	Ro-Neet	6 lb./gal. EC, 10% G	Moderate	3,160	>4,640
dalapon (Dow)	Dowpon M	74% WSP	Moderate	7,570	
DCPA (Diamond Shamrock)	Dacthal	75% WP, 5% G, 2.5% G	Mild	3,000	>10,000
dicamba (Velsicol)	Banvel	4 lb./gal. S, 5% G	Moderate	1,028	
dichlobenil (Uniroyal)	Casoron	50% WP, 4 & 10% G	Mild	3,160	1,350
diclofop (Hoechst)	Hoelon	3 lb./gal. EC	Moderate	2,176	>5,000
dichlorprop (Union Carbide)	Weedone 2,4-DP	4 lb./gal. EC	Mild	800	1,400
dinoseb (DNBP) (Vertac)	Premerge	3 lb./gal. S, 5 lb./gal. EC	Moderate	59	>75
diphenamid (Elanco) (Upjohn)	Dymid Enide	80% WP	Mild	970	>6,320
diquat (Chevron)	Ortho Diquat	2 lb./gal. S	Moderate to severe	230	>400
diuron (DuPont)	Karmex	28% L	Mild	3,400	
DSMA (Diamond Shamrock)	(several)	3 lb./gal. S, various WSP	Mild to moderate	1,000	
endothall (Pennwalt)	Endothal Aquathol Hydrothal	(various EC & G)	Moderate	182 to 206	
EPTC (Stauffer)	Eptam Eradicane	7 lb./gal. EC, 2.3,5 & 10% G, 6.7 lb./gal. EC	Mild	1,652	10,000

(See footnotes on first page of table.)

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute oral LD_{50}[e]	Acute dermal LD_{50}[f]
ethalfluralin (Elanco)	Sonalan	4 lb./gal. EC	Moderate	>10,000	>2,000
fenuron TCA (Hopkins)	Dozer	3 lb./gal. L, 25% P	High	4,000	
fluazifop (ICI Americas)	Fusilade	4 lb./gal. EC	Mild	4,350	>2,000
fluchloralin (BASF)	Basalin	4 lb./gal. EC	Mild	1,550	
fosamine (DuPont)	Krenite	4 lb./gal. L	Mild	24,400	>1,683
glyphosate (Monsanto) (Ortho)	Roundup Kleanup	3 lb./gal. S, 5% S	Moderate	4,900	>7,940
hexazinone (DuPont)	Velpar	90% WSP	Mild	1,690	>5,278
linuron (DuPont)	Lorox	50% WP, 4 lb./gal. WDL	Moderate	1,500	
MCPA (Rhone-Poulenc) (Union Carbide)	(several)	2 & 4 lb./gal. EC, 20% G	Mild	800	>1,000
MCPB (Rhone-Poulenc) (Union Carbide)	Can-Trol Thistrol	2 lb./gal. S		800	
mecoprop (Vineland) (Rhone-Poulenc)	MCPP Chipco Turf Herbicide	2 & 4 lb./gal. EC	Mild	1,060	900
mefluidide (3M)	Vistar	2 lb./gal. S	Mild	4,000	>4,000
metolachlor (CIBA-Geigy)	Dual	8 lb./gal. EC	Mild	2,828	>10,000
metolachlor + atrazine (CIBA-Geigy)	Bicep	2 + 2.5 lb./gal. WDL			
metribuzin (Mobay) (DuPont)	Sencor Lexone	50% WP, 4 lb./gal. WDL, 75% DF	Mild	1,090	
monuron TCA (Hopkins)	Urox	3 lb./gal. oil concentrate, 5.5% G, 22% G	High	2,300	1,000
napropamide (Stauffer)	Devrinol	2 lb./gal. EC, 50% WP, 10% G	Mild	5,000	>4,640
naptalam (NPA) (Uniroyal)	Alanap	2 lb./gal. EC, 10% G	Mild	1,770	
naptalam and dinoseb (Uniroyal)	Dyanap	2 lb./gal. + 1 lb./gal. EC	Mild	232	
nitrofen (Rohm & Haas)	TOK	2 lb./gal. EC, 50% WP	Moderate	1,470	
oryzalin (Elanco)	Surflan	75% WP, 4 lb./gal. WDL	Mild	10,000	>2,000
oxadiazon (Rhone-Poulenc)	Ronstar	2 lb./gal. EC	Severe	2,310	8,000
oxyfluorfen (Rohm & Haas)	Goal	2 lb./gal. EC	Mild	5,800	>3,000
paraquat (Chevron)	Ortho Paraquat	2 lb./gal. S	Moderate	120	>480

(See footnotes on first page of table.)

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Dermal irritation[d]	Acute oral LD_{50}[e]	Acute dermal LD_{50}[f]
pebulate (Stauffer)	Tillam	6 lb./gal. EC, 10% G	Severe	1,390	>2,000
pendimethalin (American Cyanamid)	Prowl	4 lb./gal. EC	Mild	1,050	>5,495
phenmedipham (Nor-Am)	Betanal	1.3 lb./gal. EC		>8,000	>4,000
picloram (Dow)	Tordon 22K Tordon 10K	2 lb./gal. EC, 10% G	Mild	8,200	>4,000
prometon (CIBA-Geigy)	Pramitol	2 lb./gal. EC, 80% WP	Mild	2,980	
pronamide (Rohm & Haas)	Kerb	50% WP	Mild	5,620	>3,160
propachlor (Monsanto)	Ramrod	4 lb./gal. F, 20% G	Moderate	710	>5,010
propazine (CIBA-Geigy)	Milogard	4 lb./gal. WDL, 80% WP	Mild	5,000	
pyrazon (BASF)	Pyramin	80% WP		3,600	
sethoxydim (BASF)	Poast	1.53 EC		2,676	
siduron (DuPont)	Tupersan	50% WP	Moderate	7,500	
silvex (Dow) (Union Carbide)	Kuron Weedone 2,4,5-TP	4 & 6 lb./gal. EC	Moderate	650	
simazine (CIBA-Geigy)	Princep Aquazine	4 lb./gal. WDL, 80% WP, 4 & 10% G	Mild	5,000	10,200
sodium chlorate	(several)	4,19 & 28% L, 99% powder	Moderate	1,200	
tebuthiuron (Elanco)	Spike	80 W, 1% G, 5% G	Mild	644	>200
terbacil (DuPont)	Sinbar	80% WP	Mild	5,000	>5,000
terbutryn (CIBA-Geigy)	Igran	80% WP	Mild	2,500	>10,200
trichlopyr (Dow)	Garlon	3 & 4 lb./gal. EC	Mild	2,140	
trifluralin (Elanco)	Treflan	4 lb./gal. EC, 5% G	Mild	3,700	>5,000
vernolate (Stauffer)	Vernam	7 lb./gal. EC, 10% G	Severe	1,780	4,640
2,4-D (Dow)	(several)	(various L, G)	Moderate	300 to 1,000	
2,4-DB (Union Carbide) (Rhone-Poulenc)	Butyrac Butoxone	2 lb./gal. EC	Mild	1,960	>10,000
2,4,5-T (Dow)	(several)	(various L)	Mild	300	

(See footnote on first page of table.)

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Mixing Agricultural Chemicals

There is considerable interest in tank-mixing agricultural chemicals. This practice allows application of two or more chemicals together, saving time, money, and labor. Two questions are often asked about tank-mixing: "Are tank mixes legal?" and "Are tank mixes practical?"

The act regulating pesticides (FIFRA-Federal Insecticide, Fungicide, and Rodenticide Act) was greatly changed in 1972 to place more responsibility on pesticide users. One of the changes made it illegal for a user to apply a pesticide in a manner that is "inconsistent with its labeling." In other words, the pesticide label became the law, and the applicator had to be very careful to follow all label directions. The legality of many popular practices, such as unlabeled tank mixes, suddenly became questionable.

Recent amendments to the pesticide act have made it more flexible, but they place more liability on the applicator. For example, herbicide tank mixes not listed on a herbicide label but not specifically prohibited on the label can be used by the applicator. Pesticides can be used to control a pest (weed, insect, or disease organism) not listed on a label as long as they are used only on the crops listed on the label. Rates lower than label rates can now be used without violating the law. However, the applicator assumes all responsibility and liability for the application; the manufacturer will not stand behind the performance of the product since the product was not used exactly according to the label.

The recent amendments also affect the tank-mixing of pesticides with fluid fertilizers. A pesticide may now be tank-mixed with fertilizers--even if the label doesn't describe such application--as long as the label doesn't prohibit its application with fertilizers and as long as all other label provisions are followed. Pesticides can now be applied by air if other label directions are followed, unless the label prohibits aerial application. Again, the applicator assumes all responsibility and liability for the application.

In summary, interpretations of the pesticide act have changed from a strict "you can't do it unless the label says you can" to "you can do it unless the label says you can't" for at least some aspects of pesticide use. Pesticide manufacturers can be expected to scrutinize label directions closely and to add new prohibitions that will directly cover more aspects of pesticide application. For most aspects of pesticide use, however, the label is still the law. The pesticide must be used on the right crop; the maximum label rate cannot be exceeded; grazing restrictions and harvest intervals must be obeyed; and prescribed protective equipment must be used.

Tank mixes are practical, but optimum timing, placement, and distribution of each product in a tank mix are important considerations. One problem with tank-mixing is the failure of the products to remain uniformly dispersed (incompatibility). This incompatibility can be caused by improper mixing, inadequate agitation, or a lack of stable emulsifiers in some emulsifiable concentrates (EC). Many incompatibility problems occur when combinations of pesticides and liquid fertilizers are mixed. Improperly mixed emulsifiable concentrates and wettable powders (WP) can form a putty or paste, with an oily layer floating on the top of the tank. Some EC formulations are not stable in salty solutions such as fluid fertilizers. A few pesticides are available in special fertilizer-grade formulations that reduce incompatibility problems. Some labels specify that it is necessary to check for mixture stability. In some cases, a compatibility agent may need to be added.

The first step in determining compatibility is to read the label. You cannot mix two pesticides if the label on either one of the products states that the product should not be used with fertilizer or other pesticides. The label will not always indicate, however, whether the product can be mixed with other chemicals. In these cases, check compatibility by a "jar test." Place one pint of carrier (usually water or liquid fertilizer) in a quart jar, and add the appropriate amount of pesticide in the proper sequence: WP formulations first, liquids (L) or flowables (F) second, and EC formulations third. Shake 5 to 10 seconds after each addition. Allow the mixture to stand for 10 to 15 minutes. If incompatibility occurs in any form (flakes, sludge, gel, precipitate, etc.), the mixture should not be tank mixed. Some incompatible mixtures may be made compatible with the addition of commercial compatibility agents. Test this possibility with the "jar test" before tank mixing.

To minimize compatibility problems with tank mixes, follow the correct mixing procedures. The usual method for tank-mixing pesticides is to fill the tank at least one-half to two-thirds full with the carrier before adding any pesticide or adjuvant. If a compatibility agent is necessary, always add it before adding the pesticides. The order of adding various formulations should be as follows: WP formulations first; L or F formulations second; water-dispersible granules (WDG) or dry-flowables(DF) third; and solutions (S), surfactants, and EC formulations last. Each product must be well mixed before the next is added. Before adding ECs to liquid fertilizer, premix them with water to form a slurry.

To make sure that you have a uniform spray mixture at all times, keep the mixture agitated during application, and do not allow it to stand overnight without agitation. If possible, apply all of a tank mixture in one day.

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Persistence of Herbicides in Soil

The soil persistence of a herbicide is the length of time it remains active in the soil, that is, its active life. Farmers must consider persistence in using both preemergence and preplant herbicides. Long persistence is desirable when it allows season-long weed control. When a herbicide extends past the growing season, however, and leaves a carryover or residual toxicity, it may damage succeeding susceptible crops. Persistence therefore involves not only length of weed control but also the possibility of soil residues.

It is sometimes desirable to have long persistence, especially in corn planted early in wide rows. A longer period of weed control is essential because the rows are shaded less rapidly in wide-row culture than in narrow-row culture. In narrow-row culture, so long as the initial control is adequate, the herbicide rate may possibly even be reduced because long persistence is not needed.

Anything that affects the rate of disappearance or loss of activity of a herbicide will affect its persistence. Soil, climatic conditions, and herbicidal properties all have such an effect.

The soil factors may be divided into three categories—physical, chemical, and microbial. The physical conditions are soil composition (sand, silt, clay, and organic matter content), moisture-air relationships, and soil temperature. The chemical properties are pH, cation exchange capacity, and kind of clay. The microbial properties are the kind and amount of microorganisms plus the microbial environment, which consists of nutrients, temperature, and moisture. The climatic variables are primarily moisture, air temperature, and sunlight. The properties of the herbicide that affect its persistence are water solubility, vapor pressure, and susceptibility to chemical or microbial alteration or degradation.

Because the application rate and uniformity of distribution affect the concentration of the herbicide at a given place, accurate calibration and uniform distribution are essential. You must know how much *to* apply and how much you *do* apply.

The processes that are involved in decreasing the persistence of a herbicide are (1) volatility, (2) photodecomposition, (3) adsorption, (4) leaching, (5) plant uptake, (6) microbial decomposition, and (7) chemical decomposition.

Volatility is the process whereby the herbicide changes from a solid or liquid to a gas. It is associated with the vapor pressure of the chemical and increases with temperature. Photodecomposition is the breakdown of the herbicide by sunlight; thus the extent of exposure to sunlight is the primary variable. If a herbicide is subject to appreciable losses by either or both of these processes, then incorporation can help to reduce the loss. Such chemicals as Sutan+ and Vernam are incorporated because of their volatility.

Adsorption is the binding of a herbicide to the surface of a clay or organic matter particle. The strength and extent of the binding and the ease with which the material

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is replaced or released will affect the rate needed to control weeds and also the herbicide's persistence in a given soil. Soils vary greatly in their adsorptive capacity, depending on the kind and amount of clay and organic matter. Herbicides that are adsorbed to a large extent are atrazine, Lorox, and Treflan; thus their rates of application must be adjusted to conform with the soil type.

Leaching occurs when a herbicide is dissolved in water and moves down through the soil profile. The primary factors involved in leaching are the amount of available water, the soil texture, the water solubility of the herbicide, and the degree of adsorption of the herbicide. A small amount of leaching is desirable to move the herbicide from the soil surface into the top 1 or 2 inches of soil, where most weed seeds germinate. However, if the herbicide leaches past the area of germinating weed seeds into the area of germinating crop seeds, then the crop may be injured if its tolerance is not adequate. On the other hand, herbicides that have low water solubility and that are strongly adsorbed may never reach the desired zone without adequate rainfall or incorporation.

Plant uptake, that is, absorption of the herbicide by the plant roots, reduces the concentration of the herbicide in the soil. The persistence may be less if the herbicide is broken down (metabolized) by the plant or if the top growth is harvested and removed from the field. Thus, for example, if atrazine is applied at the same rate in a heavy quackgrass infestation as in a light infestation, the persistence will be less in the heavy infestation. This principle may sometimes be used to reduce the amount of herbicide residue in the soil.

Microbial decomposition occurs when the soil microorganisms utilize the herbicide as a source of food or energy. If the right kind and number of microorganisms are present and if soil conditions are favorable for the microorganisms, then a herbicide may be rapidly decomposed in the soil. Herbicides vary greatly, however, in their susceptibility to microbial decomposition. For example, 2,4-D lasts only a short time in the soil, while atrazine degradation is quite slow.

Some forms of chemical decomposition are hydrolysis, oxidation, and reduction. Many soil chemical and physical conditions, such as moisture, aeration, pH, temperature, and organic matter content, regulate the rate of chemical and microbial decomposition.

Because many factors and processes are involved in the persistence of a preemergence herbicide, it is impossible to give the exact length of persistence for a particular herbicide. The approximate time can be estimated, however, for a given set of conditions. The table on the next page shows the approximate length of active life of some corn and soybean preemergence herbicides at commonly applied rates. These values are estimated for average Illinois conditions.

Average Persistence of Herbicides[a]

Name: Trade	Name: Generic[b]	Rate (lb. a.i./A[c])	Time of application[d]	No. months of persistence
AAtrex	atrazine	1 to 4	PPI, PrE, PoE	2 to 8
Alanap	naptalam	2 to 8	PrE	1 to 1.5
Amiben, Vegiben	amiben	2 to 3	PrE	1.5 to 2
Amino Triazole, Weedazol	amitrole	2 to 10	PoE	0.5 to 1
Balan	benefin	0.75 to 1.5	PPI	4 to 5
Banvel	dicamba	0.25 to 4	PrE, PoE	1 to 3
Basagran	bentazon	0.5 to 1.5	PoE	0 to 1
Basalin	fluchloralin	0.5 to 1.5	PPI	3 to 6
Bladex	cyanazine	1 to 4	PrE, PPI, PoE	1 to 2
Blazer	acifluorfen	0.75 to 1.0	PoE	1/2 to 1
Casoron	dichlobenil	2 to 6	PrE, PoE	2 to 6
Dacthal	DCPA	6 to 10	PrE	2 to 3
Devrinol	napropamide	1 to 8	PPI, PrE	4 to 8
Dowpon M	dalapon	5 to 10	PoE	0.5 to 1
Dual	metolachlor	1.5 to 3	PPI, PrE	1 to 3
Enide, Dymid	diphenamid	4 to 6	PrE	3 to 6
Eptam, Eradicane	EPTC	2 to 4	PPI	1.5 to 2
Evik	ametryn	1.5 to 2	PoE	1 to 3
Furloe Chloro IPC	chlorpropham	2 to 8	PPI, PrE	0.5 to 1
Garlon	trichlopyr	4 to 6	PoE	2 to 8
Goal	oxyfluorfen	0.5 to 1	PrE	1 to 2
Hoelon	dichlofop	1.0 to 1.25	PoE	1/2 to 1
Hyvar-X	bromacil	4 to 20	PrE	2 to 18
Igran	terbutryn	1.2 to 2.4	PrE, PoE	1 to 3
Karmex	diuron	2 to 4	PrE	3 to 6
Kerb	pronamide	1 to 2	PrE	2 to 6
Lasso	alachlor	2 to 4	PPI, PrE	1 to 2
Lorox	linuron	0.5 to 3	PrE, PoE	2 to 4
Milogard	propazine	1 to 2	PrE	8 to 12
Modown	bifenox	1.60 to 2	PrE	1 to 2
Paraquat	paraquat	0.5 to 1	PoE	0 to 0.5[e]
Pramitol	prometon	10 to 25	PrE	2 to 18
Premerge-3	dinoseb (dinitro)	6 to 9	PrE, PoE	0 to 0.5
Prefar, Betasan	bensulide	4 to 6	PrE	6 to 12
Princep	simazine	1 to 4	PPI, PrE	2 to 8
Prowl	pendimethalin	1 to 2	PPI, PrE	2 to 6
Pyramin	pyrazon	2 to 4	PrE	1 to 2
Ramrod	propachlor	4 to 6	PrE	1 to 1.5
Roundup	glyphosate	1 to 4	PoE	0 to 0.5
Sencor, Lexone	metribuzin	0.125 to 1	PPI, PrE	1 to 4
Sinbar	terbacil	1 to 8	PoE	5 to 6
Spike	tebuthiuron	1 to 16	PrE	4 to 18
Surflan	oryzalin	0.75 to 1.5	PrE	3 to 6
Sutan+	butylate	2 to 4	PPI	1.5 to 2
Tenoran	chloroxuron	1.5 to 3	PoE	1 to 3
Tillam	pebulate	3 to 5	PPI	1.5 to 2
TOK	nitrofen	3 to 6	PoE	1 to 2
Tordon	picloram	0.25 to 2	PoE	2 to 18

The footnotes for this table are on the following page.

Average Persistence of Herbicides[a] (Continued)

Name		Rate	Time of	No. months of
Trade	Generic[b]	(lb. a.i./A[c])	application[d]	persistence
Treflan	trifluralin	0.5 to 1	PPI	3 to 6
Tupersan	siduron	2 to 12	PrE	1 to 3
Velpar	hexazinone	2 to 10	PrE	2 to 8
Vernam	vernolate	2 to 4	PPI, PrE	1 to 2
Vistar	mefluidide	0.25 to 0.50	PoE	1/2 to 4
	2,4-D	0.5 to 2	PoE	1 to 2
	2,4,5-T	0.5 to 4	PoE	2 to 4
	silvex	0.5 to 4	PoE	2 to 4

[a]Normal Illinois conditions, medium-textured soil.
[b]Generic refers to the common name approved by the Weed Science Society of America.
[c]a.i./A means active ingredient per acre.
[d]PPI means preplant incorporated; PrE, preemergence; PoE, postemergence.
[e]Inactivated in soil but still present for several months.

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Testing for and Deactivating Herbicide Residues

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Residues of triazine herbicides (such as atrazine and simazine) or of substituted-urea herbicides (such as linuron and diuron) may persist in the soil for long periods. Cyanazine (Bladex) has been shown to have a shorter residual period than atrazine and, therefore, should be considered when planning rotations of corn and vegetables.

Attempts have been made to correlate residue persistence with rainfall, temperature, soil characteristics, cultivation practices, method and time of herbicide application, and rate of application. Thus far, however, predicting the extent of residue damage to sensitive crops the year following residual herbicide applications has been only partially successful.

Testing for Herbicide Residues

Chemical analyses for herbicide residues are slow and quite complicated. Such tests can be done in only a few specialized laboratories and usually are expensive.

Biological assays are more feasible, since they can be done with simple equipment found in most homes or offices. Although the biological assay outlined here does not provide an exact measure of the amount of residue present in the soil, the assay will indicate whether enough residue is present to harm sensitive crops. The bioassay for atrazine (using oats as a test species) was published in the December, 1967, issue of *Crops and Soils*. That method can also be adapted for use when testing for other residues.

1. Secure a representative soil sample from the field suspected of having atrazine residue. Take samples from several locations in the field, as when collecting soil samples to determine fertilizer requirements. Atrazine residue may appear in patches of a field. Enough areas must be sampled to avoid missing ones with a high residue content. Headlands and knolls frequently show the most residue injury. Take separate samples from areas where excessive residues may occur. Always take the soil samples to the full depth of the plow slice, whether or not the field is plowed. You may also segment the sample into 0-2, 2-4 and 4-6 inch soil depth increments for greater accuracy. Remember that the assay is only as reliable or representative as the samples you take. Each sample to be assayed requires about 10 pounds of soil.
2. Assays should be run on the samples as soon as possible after they are obtained from the field. If the samples cannot be assayed immediately, store the soil in a cold place; if possible, allow it to freeze. When samples are stored indoors under warm conditions, the residue may be lost.
3. If the soil is wet, spread it out and allow it to dry so it can be worked readily. If the soil is cloddy, crush the clods into the size of a pea or a wheat seed, but do not pulverize the soil.

4. Adding about 50 percent by volume of coarse sand will improve the physical condition of silt and clay soils. If sand is added, mix it with the soil thoroughly.

5. Add about 1/2 gram of activated carbon to half (five pounds) of the soil or mixture of soil and sand. Mix the carbon with the soil thoroughly. The carbon deactivates the atrazine or other residue. For purposes of comparison, soil treated this way provides the equivalent of soil without residue.

6. Partially fill two containers with soil that does *not* contain carbon and two others with the soil-carbon mixture. These should be containers holding about a pint to a quart. Punch holes in the bottom of the containers to allow drainage. Tin cans, paper milk cartons, or ice cream cartons are satisfactory for this purpose.

7. Plant about 15 oat seeds (or seeds of susceptible vegetable species of specific interest) in each container and cover the seeds with about half an inch of soil. Wet the soil with water. Do not saturate the soil.

8. Place the containers in a warm place (about 70° to 75° F.), where they will get the most sunlight possible. Sunlight usually is essential for the development of atrazine-injury symptoms. Artificial light has much less intensity than sunlight and, therefore, may not be satisfactory for symptom development.

9. Injury symptoms on seedlings should become apparent about three weeks after planting. If the temperatures are below 70° F., more time is required. Water the plants sparingly. Do not allow the soil to dry out.

10. Severe atrazine injury is characterized by drooping leaves and by leaf-kill that extends from the tip of the leaf toward the base. Leaf-kill indicates the presence of a significant amount of residue in the soil. A marginal content of residue will stunt the growth of the oats without killing the leaves. Stunting can be determined by comparing the growth of oats in soil with carbon. Oats grown in soil with carbon should be normal and should show no atrazine injury or stunting, unless extremely high residues of atrazine are present in the soil sample.

11. If the oats show any evidence of leaf-kill or stunting, plant the field from which the samples were obtained with an atrazine-tolerant crop.

Using Activated Charcoal

Activated charcoal (or carbon) can reduce herbicide contamination in specific areas (gardens, greenhouses, lawns, and the like) and can also be used as a root dip to protect transplants (tomatoes, peppers, strawberries, ornamentals, and so on) in relation to triazine or substituted-urea herbicides. Activated carbon can also be used to "clean up" pesticide spills.

Other herbicides that may be deactivated by carbon include trifluralin (Treflan), bromacil (Hyvar-X), benefin (Balan), bensulide (Betasan, Pre-San, and Prefar), DCPA (Dacthal), dichlobenil (Casoron), diphenamid (Enide), EPTC (Eptam), 2,4-D, and terbacil (Sinbar).

Activated carbon, now used in a wide range of applications in diverse industries, is manufactured by heating or chemically treating organic matter to achieve a porous structure. Doing this produces a large surface area within a relatively small volume. Most activated carbons are purified by acid and water washes to remove undesirable impurities and are available in both granular and powdered form. The charcoal used with outdoor grills and the like cannot be ground up to achieve the same pore structure characteristic of activated charcoal on a pound-for-pound basis.

The usefulness of activated carbon is based primarily on its ability to absorb molecules into its vast pore structure. The phenomenon of adsorption can take place either in gaseous or liquid phase systems. The adsorption is often selective when applied to systems containing more than one component. Two examples of this are using activated carbon in gas masks to remove poisonous vapors and as an antidote for accidentally ingested poisons.

Where to Obtain Activated Charcoal

Some garden supply centers carry packaged activated carbon specifically designed for the uses outlined here. Several brands of a similar type of carbon are available.

Activated carbon is used extensively in dry cleaning and water-purification units. Usually, the names of local distributors can be found in the Yellow Pages under "Cleaners and Driers Supplies," or by contacting a dry-cleaning establishment. In emergency cases, carbon probably could be purchased directly from a local dry cleaner. However, some dry-cleaning carbons may contain additives that will make them unsuitable.

Such local businesses are an especially valuable source of carbon in rural areas, where delivery from a distributor may be slow. Activated carbon is offered in containers of 1 to 50 pounds. Small quantities of purified activated carbon are available at pharmacies and at chemical supply houses.

Application Methods

Two methods often are used to protect transplanted, susceptible species.

1. Mix activated carbon with water to make a slurry or paste (two pounds in a gallon of water). Dip the transplant roots into the paste, making sure not to get the material on the foliage. With this method, 300 small transplants usually can be treated. Set out the treated plants while the roots are still wet.

2. Mix one pound of activated carbon in several gallons of water. Use this as a transplant "solution" (pour it around the roots) for about 300 plants. Because the activated carbon must be kept in suspension by stirring, the root-dip method is usually the more practical one.

The second procedure should not be used where phytotoxic herbicides (ones harmful to the plant you want to grow) were applied for weed control the year in which a susceptible crop was planted, but only as an emergency measure to overcome a residue from phytotoxic herbicides.

The second method can be used on transplanted crops, but enough charcoal cannot be placed on many crops seeded directly to absorb the herbicide in a large enough soil volume for satisfactory root development. For the direct-seeding of susceptible species, using a band deactivation of the soil may be necessary.

Mixing activated carbon into soil contaminated with undesirable herbicide residues may significantly reduce the uptake of the residues by the crops. If an area is contaminated with a common herbicide residue and a susceptible crop is to be seeded, apply activated carbon at 200 pounds per acre (one-half pound per 100 square feet) for each pound per acre of the actual residue. (For differences between herbicides, see G.F. Warren, 1973, "Use of Activated Carbon to Inactivate Herbicide Residues," *North Central Weed Control Conference* 28:68-69.) The carbon should be uniformly incorporated to a depth of three or four inches. The efficiency of deactivation will depend on the organic-matter content and physical condition of the soil, the activity of the herbicide, and the sensitivity of the crop.

Fungicides, Disinfectants, Grain Preservatives, Surfactants, and Soil-Disinfesting Chemicals

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A fungicide is a chemical that kills or inhibits fungi. With sales of about $280 million in the United States each year, fungicides are widely used to protect plant seeds, foliage, flowers, fruits, and roots against disease-producing fungi. No single fungicide is suitable or effective against all fungi. Additional information can be found in *Report on Plant Diseases No. 1001, Seed Treatments for Field Crops* and Table 1, Soil-disinfecting Chemicals.

Fungicides are generally formulated as flowable liquids (F), emulsifiable concentrates (EC), dusts (D), granules (G), and most commonly as wettable powders (WP).

The concentration of a fungicide is expressed as a weight per unit volume or as a percent of the formulation. For example, a fifty percent wettable powder (50% WP) is half "active ingredient" (a.i.) and half inert ingredients consisting of emulsifying agent, carrier, surfactant, adjuvant, and other diluents. Liquid formulations generally indicate the number of pounds of active ingredient per gallon (lb. a.i./gal) on the label.

The actual amount of material to be applied depends on the concentration of the chemical (a.i.) in the preparation. A manufacturer may sell the same fungicide in a half dozen or more formulations where the percentage of a.i. may vary from 0.1 to 100 percent. *Be sure to read and follow the manufacturer's directions on the container label.* All formulations of a fungicide may not be registered for the same crops.

All plant disease-control chemicals should be stored in their original, closed, plainly labeled containers out of the reach of children, irresponsible adults, and animals. Avoid repeated or prolonged contact with the skin and inhalation of dusts, sprays, and vapors. Wash hands and face before eating or smoking. Do not contaminate streams, lakes, or ponds, or clean equipment near such water supplies.

Most fungicide spray programs are designed to *protect* against infection. This requires that the chemical uniformly and thoroughly cover all susceptible plant parts before penetration of the pathogen and infection occur. Rainy, foggy, or very humid weather favors the infection process of practically all fungal and bacterial pathogens. Whenever possible, spray programs should be altered to provide maximum protection during moist periods. Spray recommendations should provide acceptable control under conditions where about an inch of rain falls per week during periods of active growth. Extra sprays may be required during wet seasons, while fewer or no applications may be needed in periods when the weather is unusually dry.

Fungicides are listed by coined (generic or common) names or representative trade (brand) names. Mention of a trade name or proprietary product is for convenience only. No endorsement or warranty of products is intended nor does it imply approval of a material to the exclusion of unnamed but comparable products that may be equally suitable.

Persons using plant disease-control products assume responsibility for their use in accordance with current label directions of the manufacturer. Always read the label carefully before using these chemicals. Pay special attention with respect to children and pets. Keep them out of the area when applying any material, and check the label for any special precautions relative to keeping people and animals out of the treated area for a period of time after application. Heed advice about protective clothing and steps to take in the event of chemical spills on your body or clothing. Dispose of empty containers according to label instructions. Plant disease-control chemicals are safe to use when handled and applied strictly according to instructions on the label.

Fungicides are often divided into three groups according to their action.

Protective contact fungicides are applied to seed, foliage, flowers, fruit, or soil as sprays, dusts, or granules to control disease-causing fungi *before* they can enter plants. These materials provide protection, but may NOT (a) kill fungi established inside a growing plant or seed (exceptions: powdery mildew and sooty mold fungi that are superficial and largely on the surface of plants can be killed by surface dusts or sprays after infection has occurred); (b) protect against pathogenic fungi entering through the roots such as root rots, wilts, and clubroot of crucifers; (c) control bacterial diseases, spiroplasmas, and mycoplasmas since most fungicides are poor bactericides; (d) protect against viruses; or (e) control nematodes.

Most fungicides in use today possess protective qualities. Those that are ONLY protective include zineb (Dithane Z-78, Black Leaf Sheen), thiram (Tersan 75, Arasan, Thylate), ferbam (Karbam Black, Carbamate), ziram (Zerlate, Karbam White, Z-C Spray), sulfur, glyodin (Glyoxide), and possibly fixed or neutral copper compounds. These chemicals must be applied before an infection starts. They require frequent applications at 5- to 14-day intervals, depending on weather conditions. During rainy weather, sprays need to be applied at shorter intervals. Practically all dust and granule formulations function as protectants and should be used accordingly. Dusts should be applied when the air is calm and foliage is lightly covered with moisture. Early morning and evening are usually ideal times.

Protective contact-eradicant fungicides are applied in the same way as protective contact fungicides. However, they have another dimension of effectiveness, that of killing or inhibiting fungi after they have penetrated plants and become established. A commonly used term is "kickback," which means that an infection may be stopped after becoming established. For example, dodine (Cyprex) still provides some control if applied up to 36 hours after apple scab infection has occurred. Thus, it has a "kickback" for apple scab. In other words, dodine can prevent infection, and it also has good contact toxicity to fungus growth. "Contact toxicity" means that the compound may either kill or merely inhibit further growth. The list of protective contact-eradicant fungicides includes a large number of the most popular ones.

Examples are cycloheximide (Acti-dione), benomyl (Benlate, Tersan 1991), captan (Orthocide), captafol (Difolatan), dodine, dinocap (Karathane), folpet (Phaltan), lime-sulfur, maneb (Dithane M-22, Manzate), mancozeb or maneb plus zinc ion (Manzate 200, Dithane M-45, Fore), thiabendazole or TBZ (Mertect), thiophanate compounds (Topsin-M, Zyban, Cleary's 3336), Dikar, Niacide M, Polyram, Botran, and such seed treatments as formaldehyde and hot water. Some of these also have good residual and systemic properties.

Systemic fungicides, or chemotherapeutants, are chemicals that are absorbed and distributed within the plant to control a disease for several weeks or months. Only a few chemicals now available act in this way. Examples are triadimefon, cycloheximide, benomyl, thiabendazole, thiophanate compounds, chloroneb (Demosan, Tersan SP), carboxin (Vitavax), metalaxyl, pyroxyfur, and oxycarboxin (Plantvax). To be effective, a systemic fungicide must be taken up by the seed, foliage, roots, or stem(s) of the plant and be translocated in an active state to where infection occurs.

Streptomycin, an "antibiotic" bactericide, is topically systemic when applied to foliage. This means that streptomycin can be absorbed by leaf tissue to inhibit bacterial infection, but does not move systemically from leaf to leaf.

Commonly Used Fungicides and Their Principal Uses

Many new fungicides have been introduced into American agriculture since 1950. These chemicals have largely replaced old standbys such as bordeaux mixture; fixed or neutral coppers; dinitro materials; lime-sulfur; and wettable, dust, or paste sulfurs. The older materials are messy to handle and corrosive to spray equipment. They also cause injury to plants under cold, hot, or slow-drying conditions, and may often reduce the quality and quantity of the crops they were designed to protect. Unfortunately, some retail outlets still stock outmoded fungicides and carry only a few of the safer and more effective fungicides—captan, zineb, maneb, mancozeb, dodine, folpet, thiram, chlorothalonil (Daconil 2787, Bravo), benomyl, and other products listed below.

Fungicides are marketed under a bewildering assortment of trade names. To help relieve confusion, a set of common (generic) or "coined" names has been officially adopted and is now widely used on package labels in place of, or with, the more complicated chemical names.

The following list and the paragraphs immediately below it summarize the common names, active ingredients, trade names, and principal uses of the more commonly used fungicides.

Fungicides that have no common (generic) name, i.e. have a trade name that does not include a common name, or are not widely used at present to treat seed, foliage, flowers, fruit, or soil, are listed alphabetically in Fungicides of Less General Use.

This listing is incomplete since there are about 35,000 disease-control products now registered by the Pesticides Registration Division of the Environmental Protection Agency (EPA) in Washington, D.C. and many additions, deletions, and other changes are made monthly. Some of the products listed may no longer be manufactured, but may still be available in certain retail outlets or directly from the manufacturer. Should you need more detailed information (manufacturers, sources), or information on plant disease-control products not listed, please contact your state extension plant pathologist.

The effectiveness of fungicides on foliage, seed, and in soil is determined by timing, dosage, where and how applied, weather, type of tillage system, how well the treatment is matched to the disease problem and soil situation, and other factors. Proper consideration of all these factors is essential for maximum benefits from these chemicals.

Most of the chemicals listed are "pure" compounds; only a relatively few contain mixtures of more than one fungicide or fumigant. Little attempt has been made to include the thousands of "multipurpose" pesticides that include mixtures of insecticides, miticides, and fungicides.

ANILAZINE [*4,6-dichloro-N-(2-chlorophenyl)-1,3,5-triazine-2-amine or 2,4-dichloro-6-(o-chloranilino)-s-triazine*]

A broad-spectrum, protective foliar fungicide useful in controlling many turfgrass diseases plus some anthracnoses, Botrytis blights, fungus leaf spots, and blights of many vegetables, woody ornamentals, flowers, bush and bramble fruits, and strawberries. *Trade names*. Dyrene 50% Wettable Powder Foliage Fungicide; Agway Granular Turf Fungicide With Dyrene; Patterson's Turf Fungicide W/Dyrene; Dyrene Lawn Disease Control; Scotts ProTurf Fungicide III; Dymec 50 Turf Fungicide; Dyrene Turf Fungicide.

BENOMYL [*Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate*]

A very low toxicity, broad-spectrum fungicide that is preventive, curative, long lasting, and systemic. Benomyl is effective at very low dosages against a wide range of fungus leaf spots, blotches and blights; fruit spots and rots; sooty molds; scabs; bulb, corm and tuber decays; blossom blights; powdery mildews; Botrytis blights; Verticillium and Fusarium wilts of annuals; anthracnoses; certain rusts; common soil-borne crown and root rots; clubroot of crucifers, and a number of turf diseases. Benomyl also prevents certain fungi, (e.g., the apple scab fungus) from sporulating. Because exclusive use of benomyl has frequently led to the development of tolerant strains of fungi, another fungicide is added to benomyl.
Trade names. DuPont "Benlate" Benomyl Fungicide; Tersan 1991 Turf Fungicide; Bonide Benomyl (DuPont New Systemic Fungicide); Science Benomyl Systemic Fungicide; Rockland Benomyl Fungicide; Benomyl Turf Fungicide Granules; Miller's Benomyl Systemic Fungicide, Patterson's Benomyl Systemic Fungicide; Scotts ProTurf fertilizer plus DSB Fungicide. *MBC-phosphate (carbendazim) products* for injection treatment as an aid in control of Dutch elm disease (formerly Lignasan BLP) include Hopkins Correx Fungicide, Agway Elmosan, Pratt Elm Tree Noculate, Arboral Fungicide, and Lily/Miller Ulmasan. All contain 0.7% methyl 2-benzimidazolecarbamate phosphate, a close relative of benomyl. These products are *only* to be used by trained arborists and others trained in injection techniques.

Benlate T contains 20% benomyl and 20% thiram.

BORDEAUX MIXTURE

A broad-spectrum, long-lasting, protective fungicide now used mostly as a soil drench, dormant spray, and foliar spray to control needle diseases of conifers. It may "scorch" foliage and russet fruit of some plants, e.g., many flowers, hollies, and maples in cold, damp weather. Injury is worse on plants weakened by disease, insect, or mite injury. Bordeaux is most effective when freshly mixed. It is also used as an insect repellent, as an emulsifier in dormant oil sprays, and as a general disinfectant for work surfaces, storage cellars, and other areas.

Trade names. Prepared dry bordeaux products include Acme Bordeaux Mixture; Patterson's Bordeaux Mixture; Copper Hydro Bordo; Bor-dox; Pratt Bordeaux Mix; Black Leaf Bordeaux Powder; Ortho Bordo Mixture. [Bordeaux is a mixture in water of copper sulfate crystals (bluestone or blue vitriol) or powder ("snow") and hydrated spray lime. The formula is written in figures (e.g., 8-8-100). The first figure is copper sulfate in pounds, the second is spray lime in pounds, and the last number is water in gallons.]

BOTRAN (DCNA) [2,6-dichloro-4-nitroaniline]

A foliar, seed, soil, and post-harvest fungicide that controls a range of seed decays and seedling blights; stem (crown), fruit, bulb or corm rots; and blights of certain vegetables, tree and bush fruits, and ornamentals caused by species of *Botrytis, Monilinia, Rhizopus, Sclerotinia,* and *Sclerotium*. Also effective as a cut-flower spray or dip for Botrytis control. Botran may injure some tender crops.
Trade names. Botran 50% WP, Botran 75W, Botran 75WP, E-Z-Flo Botran 6 Dust. Bo-Cap and Botec Peanut Seed Protectant are 30:30 mixtures of Botran and captan, while Orthocide Botran 35-35 Seed Protectant contains 35% each of Botran and captan. Ortho Difolatan Botran 20-60 Seed Protectant and 35-35 Seed Protectant contain 20%-60% and 35% each of Botran and captafol, respectively.

CAPTAFOL [N-[(1,1,2,2-tetrachloroethyl)thio]-4-cyclohexene-1,2-dicarboximide]

A very long-lasting, protective contact-eradicant foliar, fruit, seed, and soil fungicide related to captan and folpet. Controls downy mildews, numerous fungus leaf spots and blights, blossom blights, fruit spots and rots, scabs, anthracnoses, seed rot, damping-off, and gray molds (*Botrytis*) of certain tree and bush fruits, vegetables, and ornamentals. Some persons are allergic or become sensitized to captafol. Avoid contact with eyes, skin, or clothing.
Trade names. Ortho Difolatan 4 Flowable; Ortho Difolatan 4 Flowable Seed Protectant. Difolatan-Botran contains a 60-20 mix of these two fungicides.

CAPTAN [N-[(trichloromethyl)thio]-4-cyclohexene-1,2-dicarboximide]

Excellent, low toxicity, broad-spectrum, moderately residual fungicide to control a wide range of leaf and blossom blights, leaf and fruit spots, blotches, anthracnoses, sooty molds, flyspecks, certain downy mildews, scabs, fruit rots, leaf curls and galls on bush and tree fruits, flowers, trees, shrubs, and turf. Seed, corm, tuber, and bulb protectant (often mixed with an insecticide) for vegetables, ornamentals, cereals, and grasses. Pre-harvest packing box treatment and post-harvest dip, spray, or wash for many fruits and vegetables. Does NOT control powdery mildews and rusts. Applied as a dust or drench to soil in plant beds to control crown rot, damping-off and seedling blights—often in combination with PCNB. Widely used in multipurpose sprays and dusts, especially for fruits and flowers. Available primarily as wettable spray powders, dusts, and special flowable seed protectants. Both a protectant and a mild eradicant. Captan is more effective against *Botrytis* under low temperatures (48°-50° F) than some other fungicides.
Trade names. Stauffer Captan 50-WP, 80-WP, Captan-Moly-Planterbox Treater, Captan-Thiram 43-43 WP & Dust; Captan 25, 75, and 80 Seed Protectant; Captan Garden Spray; Evershield Captan Seed Protectant; Gallotox Captan FP-700R; Captan 80 Spray-Dip; Orthocide 50 and 80 Wettable; Orthocide Fruit and Vegetable Wash; Agway Captan 5D and 7.5D; Orthocide 65 and 75 Seed Protectant; Miller's Captan 50W; Patterson's Captan Garden Spray; F & B Captan 7.5 Dust and Captan 50-WP; Chipman Captan Dust; Hopkins 7-1/2% Captan Dust; Orthocide 5 Dust, 7.5 Dust, 10 Dust, 15 Dust, and 80 Concentrate; Occidental Captan; Security Captan; Miller's Captan Dust and Captan Garden Dust; Bonide Captan 50W; E-Z-Flo Captan 7-1/2 Dust; Captan 25 Planterbox

Treater; Hopkins 25% Captan Seed Protectant and Captan-Moly Planter Box Seed Protectant; Farmrite Captan 5% and 10% Dust; Green Cross 7.5% Captan Dust; Ortho Soybean Seed Protectant and (MO); Orthocide Potato Seed Treater; Orthocide 90 and 92 Seed Protectant Concentrate; Orthocide 4 Flowable Seed Protectant; Security 7-1/2% Captan Peach Dust; Naco Captan 7.5 Dust; Chevron 90 Concentrate; Vancide 89.

Orthocide Vitavax 20-20 is a mixture of captan and carboxin. Agrosol-S, Granox, and Orthocide Maneb 30-30 Seed Protectant are 30:30 mixtures of captan and maneb. Granox P-F-M is a 30:30 combination of captan and maneb with 1% molybdenum.

CARBOXIN [5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide or 2-3-dihydro-5-carboxanilido 6-methyl-1,4-oxathiin]

A protective contact-systemic fungicide effective against various seed- and soil-borne smuts (including loose smut of wheat and barley), some seed-rotting and seedling blight fungi, some rusts, common scab of potato, Rhizoctonia damping-off of seedlings, and Verticillium wilt of annuals. Applied to seeds or soil at planting time. It is registered for use on barley, corn, cotton, oats, peanuts, rice, soybeans, and wheat.
Trade names. Vitavax Fungicide; Vitavax-25 DB Fungicide; Vitavax-EVS Concentrate; Vitavax Flowable Fungicide; Vitavax-17 Flowable Fungicide; Evershield V Seed Protectant.

Vitavax-200 Fungicide contains 37.5% carboxin and 37.5% thiram, while Vitavax 200 Flowable Fungicide contains 17% each of carboxin and thiram.

Orthocide Vitavax 20-20 contains 20% each of carboxin and captan. It is registered for wheat, oats and barley as a drill-box treatment.

CHLORONEB [1,4-dichloro-2,5-dimethoxybenzene]

A protective, locally systemic seed and soil fungicide that controls pre- and post-emergence damping-off (seedling blights), and root rots of vegetables, soybeans, and ornamentals, as well as Fusarium patch, Pythium blight and snow molds of turfgrasses.
Trade names. Demosan 65W Chloroneb Fungicide; Scotts ProTurf Fungicide II; Tersan SP Turf Fungicide, etc.

Demosan T Seed Fungicide contains 40% chloroneb and 22.5% thiram.

CHLOROTHALONIL [2,4,5,6-tetrachloroisophthalonitrile]

Excellent, very low toxicity, broad-spectrum, protectant fungicide to control many fungus leaf spots and blights, blossom blights, scabs, anthracnoses, fruit spots and rots, gray-molds (*Botrytis*), certain rusts, powdery and downy mildews of turfgrasses, flowers, trees, shrubs, vegetables, and certain fruits. Gives poor control of soil-borne fungi because of rapid breakdown. Use cautiously; some cases of dermatis reported with all formulations.
Trade names. Daconil 2787; Daconil 2787 Flowable Fungicide; Bravo W-75; Bravo 6F; Turf Disease Control; Exotherm Termil; Diamond 75% Chlorothalonil; Scotts ProTurf 101V broad spectrum fungicide and ProTurf fertilizer plus 101 broad spectrum fungicide. Exotherm Termil is a special formulation (20% chlorothalonil) for use in closed greenhouses to control *Botrytis* and other foliar and flower blights of many species of ornamentals and tomatoes. One can treat 1,000 square feet of greenhouse area.

COPPER (Fixed or Neutral) COMPOUNDS

Low toxicity, moderately residual, broad-spectrum fungicides and bactericides that have largely replaced bordeaux mixture and are available for use as sprays, dusts, and soil drenches. Useful for controlling a wide range of fungus leaf and fruit spots; blotches and blights; downy mildews; powdery mildews; rots; scabs; anthracnoses; rusts; and some bacterial diseases including blights of beans, pepper, tomato, lilac, and walnut. Fixed coppers are usually finely divided, relatively insoluble powders and liquids generally much more compatible with other pesticides than bordeaux, easier to mix and handle, and less corrosive to spray equipment and less toxic to tender foliage in cool, cloudy, damp weather. Spray materials usually contain 20 to 50 percent metallic copper; dusts 3 to 35 percent. The copper ion in the form of soluble salts provides the fungicidal as well as phytotoxic and poisonous properties.

Copper fungicides are also used as algicides and wood preservatives.

Federal agencies have decided that no tolerance levels need to be established for most copper compounds.

Trade names. These materials can be conveniently divided into five categories:

1. *Sulfates*--Basic Copper Sulfate, Ortho Copper 53 Fungicide, Basi-Cop, Kilcop 53, CP Basic Sulfate, Microcop, Citco Tri-Basic Copper Sulfate, Naco 53% Basic Copper Sulfate, Copper '7' Dust, Spraycop 530, T-B-C-S 53, Neutro Cop 53, Copper 53 Fungicide. Cop-O-Zinc contains copper sulfate plus zinc salt.
2. *Chlorides*--Coprantol, Aceto Copper Chloride, Copper Oxychloride, C-O-C-S, Kauri-tal.
3. *Oxides*--Kuprite; Cuprocide; Kocide 101 Wettable Powder, 606, 404 Flowable, 3% and 5% Dust, and SD Seed Dressing; Copper Oxide; Cuprous Oxide; Brown Copper Oxide; and Yellow Cuprocide. Kocide 404S is a flowable formulation containing 27% cupric hydroxide (copper equivalent 17.5%) and 15.5% sulfur for use on peanuts.
4. *Liquids,* i.e., emulsifiable--Oxy-Cop 8L, Copoloid, Cop-O-Cide, Citcop 4E, Copper-Count, Copper-Count-N, Sol-u-Cop, Carmel Formula GH-41 & Greenhouse Fogging, Emulsifiable Liquid Copper Fungicide.
5. *Miscellaneous*--Copper Oleate, GH-41 Copper Resinate, Copper Carbonate, Tri-Cop, Zinc Coposil Fungicide, Copper Zeolite.

Oxy-Cop 8LS, Copper-Count-S and -N are liquid fungicides containing 8% ammonical copper and 5% sufur.

CYCLOHEXIMIDE [*3-[2-(3,5-dimethyl-2-oxocyclohexyl)-2-hydroxyethyl]-glutarimide*]

A short residual, eradicant, highly toxic, anti-fungal antibiotic that is absorbed through plant surfaces and is distributed locally within a plant. Effective against powdery mildews, certain rusts, a number of turfgrass diseases, cherry leaf spot, and azalea petal blight. Various formulations are sold for different purposes. Acti-spray is a tablet that dissolves in water. Cycloheximide is used at concentrations as low as 1 part in a million parts of water. Plants are very sensitive to overdose with this chemical. Do *not* apply at temperatures above 85° F.

Trade names. Acti-dione PM, Acti-dione WP (Flower Fungicide), Acti-dione WP (Lawn & Turf Fungicide), Acti-dione TGF, Acti-dione TGP, Actispray. Acti-dione TGF is now registered for tank mixing with triadimefon (Bayleton) and chlorothalonil (Daconil 2787) to control a number of turfgrass diseases.

Cycloheximide-PCNB is sold as Acti-dione RZ.

DINOCAP [*2-1(1-methylheptyl)-4,6-dinitrophenyl crotonate and isomers*]

A short residual but good eradicant fungicide specific against powdery mildews of fruits, vegetables, and ornamentals. Also suppresses certain mites. Has replaced sulfur in some multipurpose sprays and dusts. Do *not* use in hot weather (above 85° F.) as dinocap may be phytotoxic. Use a wetting agent with dinocap to ensure wetting the mildew growth. Dinocap is available as a wettable powder, liquid concentrate, and dust.

Trade names. Karathane WD, Karathane Liquid Concentrate, Miller's Karathane 2D and Garden Karaspray, Dinocap 25% W.P.

Dikar is a broad-spectrum fungicide-miticide containing 4.7% dinocap and 72% mancozeb (Dithane M-45) used primarily by commercial apple growers.

Orthocide Karathane 50-6 Wettable contains 50% captan and 4.87% dinocap. It is used on fruits, ornamentals, and vegetables.

DODINE [*N-dodecylguanidine acetate*]

Controls certain foliar diseases (fungus leaf spots and blotches, scabs and anthracnoses) of various fruit and nut crops, roses, and shade trees. Gives long-lasting protection; a good eradicant. Does NOT control powdery mildews and rusts. May be sold combined with Crag Glyodin.
Trade names. Cyprex 65-W Fruit Fungicide; Agway Dodine 1D; Miller's Cyprex 4D; Naco Dodine 2, 3, 4, and 6 Dusts; Cyprex Dodine Dust; E-Z-Flo Cyprex 4 Dust; Hopkins 2% and 4% Dodine Dust; Melprex.

ETRIDIAZOL [*5-ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole*]

A low toxicity, moderately residual soil, turf and seed fungicide specific for controlling soil-borne water molds (*Aphanomyces*, *Phytophthora*, *Pythium*) that cause crown and root rots of many ornamentals and Pythium blight of turfgrasses. Etridiazol is often sold in combination with PCNB to give broad-spectrum control of seed decay, damping-off (seedling blights), and crown, stem, and root rots of many field crops, vegetables, flowers, nursery crops, and other ornamentals. Etridiazol is available as a 35% wettable powder, 25% emulsifiable, and a 4-lb/gal emulsifiable.
Trade names. Olin Terrazole Technical and Terrazole 35% Wettable Powder, Koban, Truban (30% wettable powder, 25% emulsifiable concentrate and 5% granules).

Etridiazol-PCNB mixtures include Olin Terraclor Super-X (Emulsifiable, Granular, with Di-Syston Systemic Insecticide, with Thimet Systemic Insecticide, 20-5 Dust with Graphite, with Moly, with Graphite) and Terra-Coat (L-21, L-205, SD-205) Seed Treatment Fungicides. *Banrot* is a combination of etridiazol (Truban 15%) and thiophanate-methyl (Topsin-M 25%).

FERBAM [*Ferric dimethyldithiocarbamate*]

A general-purpose, very low toxicity, long-lasting fungicide that controls a wide range of foliar diseases of flowers, trees, shrubs, and fruit, including fungus leaf spots and blotches, scabs, and rusts. Ferbam is sometimes applied as a soil drench to control damping-off and seedling blights. Is often used in multipurpose sprays. May leave an objectionable black deposit on flowers, woodwork, and other surfaces. Mostly protective in action. Controls rusts but NOT powdery mildews. Ferbam is now rather difficult to find in many garden supply stores.
Trade names. Karbam Black; Carbamate; Stauffer Ferbam 76-W; Agway Ferbam 76W and 7.6D; E-Z-Flo Ferbam 76; Ortho Ferbam 76; Allied Ferbam; Aceto Ferbam 76% and 93%; Kerr-McGee Ferbam; Olin Ferbam; Thompson-Hayward Ferbam; Grace Ferbam; Chemform Ferbam (Wettable Powder); Ferbam 76W; Ferbam 95W; Miller's Ferbam; Naco Hi-Test Ferbam Wettable Powder; Vancide FE 95-W and FE Flowable; Champion 15% Fermate Dust; Crown 15% Fermate Dust; Gold Kist Fermate Dust; Green Cross 7% Karbam Black Dust Fungicide and 76% Karbam Black Fungicide; Naco Fermate 15 Dust; Bartlett Ferbam 76W; Farmrite Ferbam 76%; Chempar Ferbam 76 Wettable Powder; Patterson's Ferbam; Security Ferbam Fungicide; Shepard Chemical Ferbam.

FENAMINOSULF [*p-Dimethylaminobenzenediazo sodium sulfonate or sodium (4-dimethylamino phenyl) diazene sulfate*]

Very persistent soil, seed, and turfgrass chemical that is fungistatic to many fungi. It controls seed decay, cutting rots, damping-off, and stem and root rots of many

ornamentals, vegetables, fruits, and turfgrasses caused by water molds (*Aphanomyces, Phytophthora, Pythium*). It is often mixed with anilazine (Dyrene) or PCNB (Terraclor). Fenaminosulf may be applied as a soil spray or drench, or blended into a dry soil mix. Apply immediately after mixing, since exposure to light results in a rapid loss of fungicide activity. Do *not* apply to plants being propagated from cuttings until the root systems are established. Formerly sold as Dexon.
Trade names. Lesan 35% Wettable Powder Turf and Soil Fungicide; Lesan 70% Wettable Powder Seed and Soil Fungicide; Lesan 70 Seed Protectant.

Patterson's Root and Crown Rot Control and Lesan-Terraclor 35-35 Wettable Powder are mixtures of Lesan and PCNB.

Lesan D contains 32% fenaminosulf and 40% chlorothalonil.

FOLPET [N-[(trichloromethyl)thio]phthalimide]

Related to captan and captafol, and used to control many of the same diseases--fungus leaf and fruit spots, rots, scabs, blights, anthracnoses, downy mildews, sooty molds and fly specks, and leaf curls and galls--on bush and tree fruits, flowers, vegetables, trees, and shrubs. A protectant-contact-eradicant fungicide that gives fair control of many powdery mildews but not of rusts. Used as a seed treatment and in plant beds to control damping-off and seedling blights.
Trade names. Ortho Phaltan Rose & Garden Fungicide; Ortho Phaltan 50 Wettable; Niagara Phaltan 50 Wettable; Stauffer Folpet 50-WP; Agway Folpet 50-W; Miller's Phaltan 50-W; Bonide Folpet 50W; "Fungitrol;" Farmrite Phaltan 50-W; Naco Phaltan Folpet 50 Wettable Fungicide; Acme Phaltan Fungicide; Science Rose and Garden Fungicide; Aceto Folpet; Chevron Folpet Wettable; Patterson's Phaltan Wettable Powder.

MANCOZEB (or MANEB AND ZINC ION) [Includes products containing zinc and maneb]

Excellent, very low toxicity, broad-spectrum, largely protective contact fungicide for controlling fungus leaf spots, blights and blotches, scabs, rusts, rots, and anthracnoses of cereals, nuts, fruits, turfgrasses, vegetables, trees, flowers, and shrubs. This material has a spectrum of activity very similar to maneb and zineb (both below). However, it is more effective. Does NOT control powdery mildews.
Trade names. Manzate 200 Fungicide; Tersan LSR Turf Fungicide; Dithane M-45; Fore; Acme Fore; Vancide Maneb Flowable; Amazin Zinc Enriched Maneb 80 Fungicide; Science Fore Lawn Fungicide; Pratt Lawn & Garden Fungicide and Liquid Maneb; Naco Potato Seed Piece Fungicide Dust; Farmrite Potato Seed Dust; E-Z-Flo Dithane M-45 Potato Seed Piece Fungicide; Hopkins Potato Seed-Piece Fungicide Dust; Security 6% Dithane M-45; Agsco Blitex Dust DM-6; Sup'-r-Flo Maneb Flowable, Formec 80 Turf & Ornamental Fungicide.

Zyban contains 60% mancozeb and 15% thiophanate-methyl.

MANEB [Manganese ethylenebisdithiocarbamate]

Excellent, general, broad-spectrum, very low toxicity fungicide used to control a wide range of foliar and fruit diseases of trees, shrubs, turfgrasses, flowers, vegetables, and some fruit and nut crops. Very useful for tomatoes, potatoes, carrots, beans, onions, vine crops, roses, chrysanthemums, and sugar beets. Used in many multipurpose mixes for vegetables, tomatoes, potatoes, flowers, and roses. Controls rusts but NOT powdery mildews. Both a protectant and an eradicant. Has the same uses as mancozeb and zineb.
Trade names. Manzate Maneb Fungicide; Manzate D Maneb Fungicide; Dithane M-22 and Dithane M-22 Special with Zinc; Sears Lawn Fungicide; Aceto Amazin Maneb 80 WP and Maneb 80 and Maneb Flowable; Patterson's Maneb Fungicide; E-Z-Flo Maneb 7 Dust; Shepard Chemical Maneb 80% WP; Pennwalt Maneb 80; Agsco DB Yellow and DB Green; Chevron Maneb; Black Leaf Maneb Fungicide; Agrisect Brand Maneb (Wettable Powders

and Dusts); Agway Maneb 4.5D; Champion 2% Maneb Dust; Miller's Dithane M22-6D and Dithane Dust; Twin Light Maneb Dust; Ortho Maneb 80 Fungicide; Science Maneb Garden Fungicide; Naco Maneb 80 Fungicide; BASF Maneb 80WP; Security Maneb Dust; Agrox N-M Drill box Non Mercurial; Polyram M; Griffin Manex; Vancide Maneb 80.

PCNB [*Pentachloronitrobenzene*]

A very long-lasting soil, turf, seed, bulb, and corm fungicide available as wettable powders, dusts, granules, and emulsifiable concentrates that controls various soil-borne root, bulb, corm, stem, and crown rots of vegetables, flowers and other ornamentals, clubroot of crucifers, potato scab and scurf, pink rot of celery, camellia and azalea flower (petal) blights, Sclerotinia dollar spot, and Rhizoctonia brown patch of turfgrasses, and damping-off (seedling blights) of many plants. PCNB is often mixed with etridiazol (see under Etridiazol), captan, ferbam, thiram, fenaminosulf (Lesan), mancozeb, Polyram, or folpet, and incorporated into soil before planting as a dust or drenching spray in the seedbed.
Trade names. Terraclor 10% Dust, 20% Dust, 40% Dust, 80% Dust Concentrate, 10% Granular, Emulsifiable, and 75% Wettable Powder; Tri-PCNB; Pearson's Green Lawn Fungicide; Fungi-clor; Turfcide 10% Granular Fungicide and Emulsifiable Fungicide; Aceto PCNB 80% and 100%; Scotts Lawn Disease Preventer, Turf Builder Plus Lawn Disease Preventer, and ProTurf New FFII; Ortho Lawn Fungicide; Terra-Coat LT-2 and 2-LF Seed Treatment Fungicide; Naco Terraclor Dust; Terraclor 2 EC and Granules.

Captan-PCNB mixtures are sold as Orthocide Soil Treater "X" and "3X"; Orthocide PCNB 10-20 Dust; Orthocide PCNB-Nutrient Spray; Stauffer Captan-Terraclor 10-10 Seed Treatment and 30-30 Seed Protectant; Terraclor 20-Captan 10 Dust; Terraclor 50-Captan 25 Wettable Powder, PCNB-Captan 25-25 Wettable Powder.

POLYRAM or METIRAM [*Zinc polyethylenethiuram disulfide complex or polyethylene polymer*]

A very low toxicity, broad-spectrum, largely protectant fungicide for application on foliage, fruit, seed, and soil. Controls rusts, scabs, sooty molds, downy mildews, a wide range of fungus leaf spots and rots, and Botrytis blights of certain vegetables, tree fruits and nuts, roses, and other ornamentals. Polyram's range of activity is very similar to mancozeb, maneb, and zineb.
Trade names. Polyram Wettable Powder; Niagara Polyram 80 WP, 7 Dust, and Seed Treater; Security Polyram; Farmrite Potato Seed Piece Treater; Gold Kist 5% Polyram Dust; Agway Polyram 7D and Polyram 80W, Naco Polyram 3.5 Dust and Polyram Dust; Polyram 80 Wettable Powder; Polyram 7 and 10 Dust; Polyram Seed Treater; Hopkins Potato Seed Treater-P Fungicide; Niagara Polyram Potato Seed Treater.

Polyram-PCNB is sold as a 10:10 dust.

STREPTOMYCIN [*Streptomycin sulfate or nitrate*]

A short residual, antibacterial antibiotic used to control fire blight of pome fruits and ornamentals, walnut blight, bacterial spots of pepper, tomato and foliage plants, bacterial wilts, blights and rots of various trees and ornamentals, and blackleg (soft rot) of potato. May cause injury to some plants. Apply only under slow-drying conditions (such as during the night) and before infections occur. Do *not* use at low temperatures, which impair its effectiveness. Streptomycin should be used alone unless it has been purchased in prepared mixes.
Trade names. Agrimycin 17; Stauffer Streptomycin; Phytomycin; Ortho Streptomycin Spray; Streptomycin Antibiotic Spray Powder; Streptomycin Wettable Powder; Ag-Strep; Agri-Strep.

Agri-mycin 100 and 500 also contain the antibiotic oxytetracycline (Terramycin).

Captan-Streptomycin 7.5-.01 Potato Seed Piece Protectant contains 7.5% captan and 0.01% streptomycin.

Agrox Strep, a planterbox seed treatment for corn, contains 5% streptomycin, 20% captan, and 21.5% diazinon.

Hopkins Bean Seed Protectant contains 25% each captan and diazinon, and 6.25% streptomycin sulfate.

SULFUR COMPOUNDS (including Liquid Lime-Sulfur)

Old-time combination fungicide-insecticide-miticide that is only protective. It controls powdery mildews, rusts, and many fungus leaf spots, blights, scabs, and fruit rots. May injure plants in hot (85° F or above), dry weather. In dust form the particles should be fine enough to pass through a 325-mesh screen.

Lime-sulfur is a combination fungicide-insecticide (scalecide) more phytotoxic than other sulfurs. It is caustic and disagreeable to apply, and will discolor paint. Now almost exclusively used as a dormant or delayed dormant spray for bramble and tree fruits, roses, and other woody plants. A reddish-brown, vile-smelling liquid, it is made by boiling hydrated lime and sulfur together. It should not be exposed to freezing. Like bordeaux, it is not compatible with many modern pesticides.
Trade names. Sulfur; Magnetic "70" and "95;" Ortho Flotox Garden Sulfur; Sulfuron; Microfine Sulfur; Corosul S; Kolodust; Kolospray; Bonsul Spray-Dust Sulphur; Naco Micronized Wettable Sulfur; Pratt Wettable Sulfur; Sperlox-S.

Kolofog contains 30% fused bentonite sulfur. Fungi-Sperse, Liquid Sulfur, and Sperlox are liquid sulfurs. Magnetic 6 and Super Six are trade names for flowable sulfur, a microfine formulation in a liquid suspension with an average particle size not more than 5 microns. Micro-Sperse contains 54% sulfur and 3% copper.

Lime-sulfur is sold as Acme Lime Sulfur Spray, Miller Lime Sulfur Solution, F & B Lime Sulphur Solution, Orthorix Spray, Security Lime Sulfur.

THIABENDAZOLE OR TBZ [2-(4-Thiazolyl) benzimidazole]

A very low toxicity, broad-spectrum, preventive-curative-systemic fungicide closely related to benomyl and used to control a variety of the same diseases. Useful as a foliar, fruit, bulb, corm, tuber, seed, and soil fungicide, and for thermal fumigation. Formulated as a 60% wettable powder, 45% flowable, and smoke generator.
Trade names. Mertect 40, 140F, 160, 260, 340F, and 360; Tecto; Thiabendazole; TBZ. Arbotect S and Arbotect 20-S, the phosphate salt of TBZ, are registered for controlling Dutch elm disease.

THIOPHANATE MATERIALS Dimethyl or diethyl [(1,2-phenylene) bis (iminocarbonothioyl)] bis carbamate]

Very low toxicity, broad-spectrum, preventive-curative-systemic fungicides closely related to benomyl and used to control a variety of the same diseases on turfgrasses, fruits, vegetables, cereals, ornamentals, and nursery crops. Formulated as wettable powders, paste, and ULV.
Trade names. Topsin-M 70W, ULV and E; Fungo 50; Cleary's 3336; Topmec 70W Turf Fungicide; Scotts ProTurf systemic fungicide; ProTurf Fertilizer plus systemic fungicide.

Banrot is a combination of etridiazol (Truban 15%) and thiophanate-methyl (Topsin-M 25%). Zyban is a combination of thiophanate-methyl (15%) and mancozeb (60%) used as a foliar spray on ornamentals and nursery crops.

THIRAM [Tetramethylthiuram disulfide]

A broad-spectrum, protective seed, bulb, corm, and tuber fungicide for field crops, vegetables, flowers, grasses, and certain tree and bush fruits. Thiram is available

as dusts, liquids, pastes, and most commonly as wettable powders. It controls many foliar and fruit diseases (leaf spots and blotches, scabs, rots) of turfgrasses, vegetables, trees, shrubs, flowers, and fruits. Controls rusts but NOT powdery mildews. Applied to soil as a dust or drench to control crown rot, damping-off, and seedling blights. Do *not* apply to produce intended for canning or deep freezing as it may "taint" the produce. Gustafson 42-S (Arasan 42-S Thiram Fungicide and Repellent) is also sold as a deer, rabbit, bird, and rodent repellent for protecting fruit trees, shrubs, nursery stock, and other ornamentals.
Trade names. Tersan 75 Thiram Turf Fungicide; Thylate Thiram Fungicide; Arasan 50-Red Thiram Seed Protectant, 50-Red ND Thiram, 42-S Thiram Fungicide and Repellent, 70-S Seed Protectant, and 75 Thiram Seed Protectant; Evershield T Seed Protectant; Agway Thiram 4.8D and Tinasad; E-Z-Flo 5% Thylate Dust; Rhodia Sup'r-Wet Thiram; Farmrite Thiram "95" and 5% Dust; Doggett Fison Turftox; Metasol Thiram 75%; Robeco Thiram 98/100%; Shepard Chemical Thiram; Occidental Thiram; Fungisan; Pearson's Moly-Stand Soybean Seed Protectant; Chipco Thiram 75; Naco Hi-Test Thiram Wettable Powder; Thiuram 75; Spotrete; Thiramad Turf Fungicide; Niagara Thiram 65 Wettable Powder; Aceto Thiram-75; Thiram 65% and Thiram-100; Miller's Thiram 65 and 75W; Vancide TM-95 and TM Flowable; Chemform 75% Thiram WP; Kerr-McGee Thiram; Science Gladiolus and Bulb Dust.

Stauffer Captan-Thiram 43-43 Seed Protectant contains 43% each of captan and thiram.

ZINEB [*Zinc ethylenebis (dithiocarbamate)*]

Excellent, very low toxicity, general, broad-spectrum fungicide for tree and bush fruits, vegetables, flowers, trees, shrubs, and nuts. Controls wide range of leaf and blossom spots, blotches, or blights, fruit spots and scabs, Botrytis blights, downy mildews, leaf curls and galls, sooty molds and fly specks, anthracnoses, rusts, black knot of stone fruits, certain turfgrass diseases, damping-off (seedling blights), and cutting rots. Will NOT control powdery mildews. Used in many multipurpose sprays and dusts for vegetables and flowers. Only protective in activity. Zineb is now becoming difficult to find in many garden supply stores.
Trade names. Dithane Z-78; Security Zineb Dust; Science Zineb Fungicide; Ortho Zineb Wettable; Black Leaf Sheen; Aceto Zineb-75 and 85%; Acme Zineb 75W Fungicide; Niagara Zineb 75 Wettable; Vancide Zineb 85% WP; Sherwin-Williams Zineb; E-Z-Flo Zineb 75; Pennwalt Zineb W-75; Miller's Zineb 6D; Stauffer Zineb 65-W and 75-W; Ortho Zineb 5 Dust; Chipman Zineb; Patterson's Zineb Wettable Powder; Chemform 65% Zineb; Chempar Zineb 75 WP; Zineb Garden Fungicide; Shepard Chemical Zineb; Agrisect Brand Zineb 75% Wettable Powder; Hopkins 15% Zineb Dust and 6% Dithane Z-78 Dust; Naco Dithane 6 and 10 Dust; D.H. 10% Dithane Dust; Gold Kist Zineb Dust No. 10; Green Cross Thiogreen Dust Fungicide; New Dragon Tomato Dust; Miller Zineb 75%; Staples Dithane Seed Treating Dust; Vancide Zineb 85; BASF Zineb 80WP; E-Z-Flo Special Mushroom Dust; Superior's Zineb 75% Wettable.

ZIRAM [*Zinc dimethyl dithiocarbamate*]

General, very low toxicity fungicide, strictly protective. Useful for certain fungus leaf spots and blights of vegetables, fruits, nuts, and ornamentals; especially good for tender seedlings. Applied as spray, dust, or soil drench. Used in some multipurpose mixes. Does NOT control rusts or powdery mildews. Ziram is now difficult to find in garden supply stores.
Trade names. Zerlate Ziram Fungicide; Karbam White; Ziram Spray Fungicide; Niagara Z-C Spray; Aceto Ziram-75 and -100; Allied Ziram; E-Z-Flo Ziram 76WP, Miller's Ziram and 95W; Wood Ridge Ziram; Cuman; Chempar Ziram 76WP; Corozate; Vancide MZ-96 and MZ Flowable; Shepard Chemical Ziram; Samincorp Ziram.

Fungicides of Less General Use

These chemicals include a large number of products with limited use. See also Disinfectants; Grain Preservatives; Lawn Fungicides; Other Soil Treatments (including Nematicides); Table 1, Soil-disinfecting Chemicals; Wetting, Spreading, and Sticking Agents (Surfactants).

Acetic acid--A liquid food and grain preservative used to prevent spoilage in storage bins and elsewhere. Formerly applied to some extent as a soil drench to control damping-off (seedling blights) of evergreen seedlings. See also Grain Preservatives.

Banrot--A very effective broad-spectrum, contact-systemic soil fungicide for greenhouse ornamentals. Contains 15% etridiazol and 25% thiophanate methyl as the active ingredients.

Binapacryl (Morocide)--An effective, long-lasting contact miticide-powdery mildewicide with low use hazard for application to certain woody plants such as fruit trees, grapes, walnuts, and cotton. Binapacryl is not poisonous to beneficial insects. It is available as a 40% liquid, 4% dust, 25% and 50% wettable powders, and a 4% emulsifiable concentrate. Binapacryl contains 2, *sec*-butyl-4,6-dinitrophenyl-3-methyl-2-butenoate as the active ingredient.

Borax (97% sodium tetraborate decahydrate)--Used somewhat as a postharvest wash for certain fruits and as a dip for sweet potato roots. Borax is applied dry to freshly cut pine stumps to prevent *Fomes annosus* root and butt rot. It is also added to boron-deficient soils; usually in combination with a fertilizer.

Bromosan--A contact-systemic turf fungicide for control of Sclerotinia dollar spot, Rhizoctonia brown patch, copper spot, and Helminthosporium-incited diseases. Contains 16.7% thiophanate and 50% thiram as its active ingredients.

Calo-clor and *Calo-Gran* contain a mixture of calomel (mercurous chloride) and corrosive sublimate (mercuric chloride or mercury bichloride) and are sold for use by certified golf course superintendents *only*. Calo-clor is a 90% wettable powder and Calo-Gran is a 2.7% granule. These products are sold to control snow molds (Fusarium patch, Typhula blight) on golf course greens, tees, and aprons. These fungicides were also formerly used to control Rhizoctonia brown patch, Sclerotinia dollar spot, and other summer turfgrass diseases. Calomel was once used as a dip for gladiolus corms to control Fusarium yellows and scab.

Dichlone (Quintar, Phygon, Phygon XL, Phygon Seed Protectant, Arcadian Dichlone)--A foliar and seed treatment fungicide for certain fruits, vegetables, ornamentals, and field crops. Closely related to chloranil. Contains 2,3-dichloro-1,4-napthoquinone as its active ingredient. Available as a wettable powder and flowable liquid. Dichlone is not used widely at present. It may be phytotoxic and is irritating to people with sensitive skin.

Dithianon (Delan, Delan-Col)--A protective contact foliar fungicide with great tenacity. Effective against many diseases of fruits, vegetables, and ornamentals but NOT against powdery mildews. Contains 5,10-dihydro-5,10-dioxonnaphtho-(2,3b)-p-dithiin-2,3-dicarbonitrile as the active ingredient. It is not marketed in the U.S.A. at present.

Dowicide-A--A post-harvest fungicidal treatment for several fruits, vegetables, and their containers. It contains 97% sodium o-phenylphenate (tetrahydrate).

Dowicide-B--A liquid fungicide used as a dip to treat gladiolus corms and other bulbs, tubers, and roots. It contains 85% sodium 2,4,5-trichlorophenate.

Dowicide 1--A disinfectant and post-harvest fungicidal dip (in wax) for commercial treatment of certain vegetables, fruits, and their containers, e.g., crates, hampers, etc. It contains 98% ortho-phenylphenol.

Du-Ter Fungicide, Dowco 186 (or TPTH)--A broad-spectrum, persistent, foliar fungicide with excellent sticking qualities, that contains 47.5% triphenyltin hydroxide or fentin hydroxide as its active ingredient. It is excellent for controlling leaf blights of potato and carrot, Cercospora leaf spots of sugar beets and peanuts, numerous foliar diseases of pecan, and is promising for use on soybeans, rice, and other crops. Du-Ter is available in a water-soluble bag and can be applied through sprinkler irrigation equipment. It exhibits antifeeding properties for many surface-feeding insects.

Etaconazole (Vanguard)--A broad-spectrum protective and systemic fungicide. Shows promise for control of a wide range of deciduous fruit and ornamental diseases.

Ethirimol (Milstem, New Milstem, Milcurb Super, Milgo, Milgo E)--A liquid systemic fungicide for controlling powdery mildew of barley and other cereals. Contains 5-butyl-2-ethylamino-4-hydroxy-6-methylpyrimidine as the active ingredient.

Fenarimol (Rubigan)--A new broad-spectrum fungicide that is highly effective against many different fungi on ornamentals, turfgrasses, and fruits. Available as a 12% EC and as a 50% WP. Its use is still largely under experimentation in the United States.

Ferrous (iron) sulfate, Copperas, Green Vitriol--Used as a foliar spray, capsules placed into the trunk, or as a ground treatment in combination with sulfur to control chlorosis resulting from an insufficiency of iron. Also used as a herbicide (against broadleaf weeds) and as a wood preservative.

Formaldehyde (formalin)--See under Disinfectants and Table 1, Soil-disinfesting Chemicals.

Galltrol-A--A new biocontrol agent for control of crown gall of various woody plants.

Glyodex 37-22W--A wettable powder fruit fungicide containing 22.5% dodine and 37.5% glyodin. Used mostly by commercial apple growers to control scab and fruit rots, and by cherry growers to control cherry leaf spot.

Glyodin--A liquid protective foliar fungicide for apples, cherries, and certain ornamentals with excellent wetting and sticking properties. It is often mixed with benomyl, dodine, Dikar, captan, or other fungicide. Glyodin, which also suppresses certain mites, contains 2-heptadecyl-2-imidazoline acetate as the active ingredient. Glyodin is often used with growth regulators (e.g., Ethrel, Alar, NAA) on fruit trees and with streptomycin for control of fire blight.

Glyoxide--A 70% wettable powder fungicide for use on apples, sour cherries, and pears. Contains 2-heptadecyl-2-imidazoline acetate as the active ingredient. Same uses as for Glyodin (above).

Harven, DHA--A post-harvest fungicide containing the sodium salt of dehydroacetic acid (DHA). Used as a dip or spray for controlling rots of certain processed fruits and vegetables. Formerly applied as a dip or wrapper impregnant.

Hexachlorobenzene (HCB or perchlorobenzene)--A dust, slurry, or liquid seed treatment used primarily on cereals to control smuts. It is often combined with captan, maneb, thiram, or other fungicide to control seed rot and seedling blight fungi. See Report on Plant Diseases No. 1001, *Seed Treatments for Field Crops*, for trade names and diseases controlled.

Iprodione (Chipco 26019, Rovral)--A broad-spectrum contact turfgrass, fruit, and ornamental fungicide with excellent activity against *Botrytis, Monilinia, Sclerotinia, Alternaria, Fusarium, Helminthosporium,* and *Rhizoctonia*. Scott's Pro Turf Fungicide VI is a granular turfgrass fungicide containing 1.3% iprodione.

Kromad--A broad-spectrum, contact, turf fungicide containing 5% cadmium sebacate, 5% potassium chromate, 1% malachite green, 0.5% auramine, 16% thiram, plus urea, ferrous sulfate, and wetting agent. See also Lawn Fungicides. Kromad is used to control Rhizoctonia brown patch, Sclerotinia dollar spot, Corticium red thread (pink patch) copper spot, and Helminthosporium leaf diseases.

Listerol Household Disinfectant--An aerosol containing a number of different chemicals including 55.53% ethyl alcohol. See Disinfectants.

Lysol--A liquid mixture of crude cresols, sometimes used for treating gladiolus corms. A 5% solution is a good disinfectant for tools. See also Disinfectants.

Metalaxyl (Subdue 2E, 5SP; Apron; Ridomil 2E)--A wettable powder or E.C., protective fungicide with systemic properties of promise for fungal diseases of potatoes, grapes, tobacco, cotton, ornamentals, turf, and hops. Fungi controlled include downy mildews, *Pythium* spp., and *Phytophthora* spp. Contains methyl D,L,N-(2,6-dimethylphenyl)-N-(2'-methoxyacetyl)-alaninate as the active ingredient.

Methocel (Seed-Coat)--A powder or fiber containing methyl cellulose used as a sticker in seed treatment and for pelleting seed such as onions.

Milcurb (dimethirimol)--A liquid eradicant-systemic fungicide for control of powdery mildews of vine crops and certain ornamentals. One soil application may give protection for 6 weeks or more. It contains 5-n-butyl-2-dimethylamino-4-hydroxy-6-methylpyrimidine as the active ingredient.

Natriphene--A foliar and soil fungicide containing 100% sodium salt of 2-hydroxydiphenyl. Used as a drench to control damping-off (seedling blights) of ornamentals, especially orchids.

Nematicide--See Table 1, Soil-disinfesting Chemicals and Other Soil Treatments (including Nematicides).

Niacide M--A wettable powder fungicide used by commercial apple and pear growers in cover sprays for controlling a variety of summer fruit spots and rots. The active ingredients include 48% manganous dimethyl dithiocarbamate, 12.4% thiram, 2.4% manganous benzothiazylmercaptide, and 2.2% 2,2'-dithiobisbenzothiazole.

Norbac 84-C--A new biological control aid for crown gall of various woody plants.

Oxycarboxin (Plantvax-5L, Plantvax-75W Systemic Fungicide)--A systemic fungicide closely related to carboxin. Contains 5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide-4,4-dioxide as the active ingredient. Oxycarboxin controls rusts on carnation and geraniums (for greenhouse use only) when applied to foliage.

Oxythioquinox (Morestan)--A long-lasting, contact, combination insecticide-miticide-powdery mildewicide primarily used on certain flowers, shrubs, strawberries, tree fruits, and other woody plants. Sold as a wettable powder containing 25% 6-methyl-2,3-quinoxalinedithiol cyclic s,s-dithiocarbonate as the active ingredient. May be phytotoxic to certain plants in hot weather, especially when used in combination with other insecticides and fungicides. A smoke generator is used to fumigate in greenhouses.

Propamocarb (Previcur-N, Banol Turf Fungicide)--A liquid systemic fungicide active against *Pythium, Phytophthora,* and *Aphanomyces* spp. Gives long-lasting control. Currently labelled only for use on turf.

Propionic acid--Liquid grain preservative often blended with acetic or another acid. See Grain Preservatives.

Pyroxyfur (Grandstand 7E)--A liquid systemic fungicide that shows promise as a seed treatment for control of *Pythium* spp., *Phytophthora* spp., *Aphanomyces* spp., and *Rhizoctonia* spp. It shows particular promise in controlling seed decay, seedling blights, and root rots of soybeans, peas, and beans. It contains 2-chloro-6-(2-furanylmethoxy)-4-(trichloromethyl) pyridine as the active ingredient.

Soil Disinfestants, Fumigants, Fungicides--See Table 1, Soil-disinfesting Chemicals.

Spectro Turf Fungicide--A blend of a contact and systemic fungicide for control of Sclerotinia dollar spot, Rhizoctonia brown patch, Helminthosporium leaf spot diseases, and copper spot. It contains 2,4-dichloro-6-(o-chloroanilino)-s-triazine (33.33%) and diethyl 4,4'-o-phenylenebis [3-thioallophanate] (16.67%) as the active ingredients.

Spray lime--Spray grade, finely divided calcium hydroxide. Used in making bordeaux mixture and as a diluent for certain dusts, e.g., Copper-Lime Dust. Also used as a safener (alkaline additive) and carrier in certain sprays. To be effective, spray lime must be freshly made, uncarbonated, and high in hydroxide content.

Spray Sticker, Spreader, Spreader-Activator, Spreader-Sticker--See Wetting, Spreading, and Sticking Agents (Surfactants).

TCMTB (Busan 30A and 72A, Cover-Up L, Thiogen, Protector 3L, Busan 30 Seed Treatment)--Emulsifiable liquids that contain 2-(thiocyanomethylthio)benzothiazole as the active ingredient. TCMTB is used mostly as a seed protectant fungicide for small grains, sorghum, cotton, legumes, sugar beets, and conifers, and as a bulb and corm dip for gladiolus, iris, narcissus, tulips, and other ornamentals. It may be phytotoxic. See also Report on Plant Diseases No. 1001, *Seed Treatments for Field Crops*.

Terramycin--An antibacterial (and antimycoplasmal) antibiotic containing oxytetracycline. Also sold as Mycoshield. Useful in controlling bacterial spot of peach and apricot. For use *only* by commercial growers. Oxytetracycline materials are promising for control of spiroplasmal and related diseases.

Triadimefon (Bayleton)--A wettable powder, protective fungicide with systemic and eradicant properties. Has excellent activity against rusts, powdery mildews, and other fungi. Shows promise for control of fruit, turf, ornamental, and small grain diseases.

Triforine (Funginex)--A foliar, locally systemic fungicide (also protectant-contact-curative) that gives excellent control of powdery mildews, scabs, rusts, fungus leaf spots, blights, and rots of ornamentals, fruits, vegetables, and cereals. Triforine is an emulsifiable concentrate that contains 18.2% N,N' [1,4,piperazinediyl-bis-(2,2,2-trichloro-ethylidene)bis [formamide]] by weight as the active ingredient.

Trimanzone--A wettable powder fungicide for foliar use on vegetables that contains 60% maneb, 10% zineb, and 10% ferbam. Controls same range of diseases as mancozeb, maneb, and zineb.

Triziman--A wettable powder fungicide for foliar spraying of vegetables. It contains 70% maneb and 10% zineb. It controls manganese and zinc deficiencies and the same range of fungal diseases as does mancozeb, maneb, and zineb.

Vinclozolin (Ronilan, Ornalin)--A broad-spectrum, protective contact fungicide. Excellent activity against *Botrytis, Monilinia,* and *Sclerotinia* spp. Currently labelled on strawberries, bulb crops, woody ornamentals, and herbaceous ornamentals.

Vorlan--A new turfgrass fungicide labeled for use against dollar spot and Fusarium patch.

Zinc sulfate--Used primarily now to control zinc deficiency problems. It is available largely as a 25.5% flake form (easily dissolved in water but tends to harden in storage) and as a 36% monohydrated form.

Zyban--A combination systemic and contact fungicide for ornamentals and nursery crops. It is available as a 75% WP containing 15% thiophanate-methyl and 60% mancozeb as the active ingredients.

Disinfectants: There are a number of different chemicals that are used to kill or inactivate bacteria and fungi on tools, equipment, potting tables, empty greenhouse benches, pots, flats, other containers, storage areas, and hydroponic equipment. These include dipping, brushing, or spraying with 70 to 100% alcohol (grain, rubbing or wood); 37 to 40% formaldehyde (1 pint in 5 gallons of water); Lysol; Listerol Household Disinfectant; potassium permanganate; and household bleach or sodium hypochlorite (Clorox, Purex, Sunny Sol), 1 pint of bleach in 1 gallon of water. Several commercial disinfectants are available. These include:

Bardac-22--Used for treating storage areas, tools, and equipment. It contains 50% didecyl dimethyl ammonium chloride and 20% isopropanol.

Germ-I-Tol--Used for treating storage areas and equipment. It contains 50% alkyl dimethyl benzyl ammonium chloride.

LF-10 (Amphyl)--Used on greenhouse benches, potting tables, walks, tools, flats, plastic pots, and automatic watering systems. A 65% solution containing a mixture of potassium ricinoleate, o-benzyl-p-chlorphenol, isopropyl alcohol, tetrasodium ethyleneamine, tetraacetate, and alcohol. Not effective against resistant resting bodies of some fungi.

Hyamine materials (e.g., Hyamine 1622, 2389 and 3500) show germicidal effectiveness against a wide range of microorganisms. They contain quaternary ammonium compounds and are used in antiseptics, germicides, algicides, detergent-sanitizers, and deodorants. These compounds are available as an 80% ethanol solution, 5% aqueous solution, and 100% crystals.

Physan--Used for treating storage areas, tools, and equipment. It contains 10% each of n-alkyl dimethyl benzyl ammonium chlorides and n-alkyl dimethyl ethyl benzyl ammonium chlorides.

Roccal--A bactericide-fungicide used for treating potato storage areas and equipment. It contains 10% alkyl dimethyl benzylammonium chloride.

Grain Preservatives: These are liquids containing propionic acid or mixtures of it with closely related acids (e.g., acetic acid) that allow early harvesting and storage of high-moisture grain to be utilized for animal feed *only* without the problems of handling and post-harvest spoilage from storage molds (primarily species of *Aspergillus* and *Penicillium*). Sold under such trade names as Aceto Propcorn, ChemStor and ChemStor III, Grain Storer P, Tenox Grain Preservatives, Ortho-Guard G.P., Grain Treet, Grain Treat, and Sentry Grain Preserver. These products are NOT for treating grain that might be used for seed, malting purposes, or human consumption. Treated grain is reduced to sample grade due to persistent odors from the chemical treatment.

Lawn Fungicides: These are usually formulated as multipurpose mixtures to control a number of lawn and fine turfgrass diseases. The more widely available and used products include anilazine (Dyrene), chlorothalonil (Daconil 2787), Kromad, iprodione (Chipco 26019), Fore, Tersan LSR and 1991 Turf Fungicides, Bromosan, Spectro, thiophanate materials (Fungo 50, Topmec 70W Turf Fungicide, Cleary's 3336, Scotts ProTurf systemic fungicide), Acti-dione Thiram and Acti-dione TGF, Sears Lawn Fungicide, Scotts ProTurf and Lawn Disease Preventer fungicides. Turf fungicides that control one to several diseases contain cadmium (Caddy, Cad-Trete, Cadminate), zineb, maneb or mancozeb, and others. See also Commonly Used Fungicides and Fungicides of Less General Use.

Surfactants or Surface-Active Agents (Wetting, Spreading, and Sticking Agents): These materials are added to spray mixes to help keep the pesticide in suspension, improve cohesiveness of the spray, and increase the wetting of leaves, fruits, and stems. They are most useful when spraying hard-to-wet foliage such as that of conifers, broadleaf evergreens, boxwood, carnation, euonymus, carnation, gladiolus, iris, narcissus, peonies, roses, cabbage, onions, peas, and peppers. These materials can be classed as nonionic, anionic, cationic, and amphoteric. Most emulsifying agents are of the nonionic type; they do not ionize. Wetting agents and detergents are mostly anionic, becoming ionized in solution with the negative molecule being of primary influence. Cationic forms are not widely used; when these materials are ionized, the positive part of the molecule is dominant. A few commercial spreader-stickers (film extenders) available for tank mixing include Aqua T Non-ionic Organic Wetting Agent, Agway Spreader-Sticker, Bio-Film Spreader-Sticker, DuPont Spreader-Sticker, Chevron Spray Sticker, Citowett Plus, Filmfast Spreader-Sticker, Miller Nu-Film-P and -17, De-Pester Spreader-Activator, Sprint-38 Spreader Sticker, Triton B-1956, Plyac Non Ionic Spreader-Sticker, Aim Spreader-Activator, Ag-Chem Activator, Spray-Stay, At-plus S26, Adsee, and R56-Spreader Sticker.

Commercial spreaders and spreader-activators include Ortho Chevron Spreader, Chipco and Rhodia Spreader-Activator, Flo-Wet, Multi-Film L and X-77, Ortho X-77 Spreader, Pinoline, Sure Spred, Tween 20, Surfactant II, Triton AF and CS-7, Fluxit, Sanomerse 80, Penex, Sur-Ten Wetting Agents, Activate 107, Neptune, At-plus, Bio-88, Buffer-X, and R-11 Spreader-Activator.

Some common stickers include Goodrite PEPS, De-Pester Sticker, and Exhalt 800.

The fungicide or other pesticide label should indicate restrictions in selection of compatible surfactants. Use these commercial preparations according to label directions. The addition of excess wetting or spreading agent may cause excessive runoff and result in a poor spray deposit.

When selecting a surfactant, consider such factors as the homogeneity of the concentrate, its storage stability, corrosion factors on storage or packaging, ease of mixing in water, effect of water hardness on the emulsion stability or dispersion, plus the use and cost of the ingredients.

Soil Treatment Materials and Methods

The purpose of soil treatment (disinfestation) is to kill disease-inciting organisms (i.e., bacteria, fungi, nematodes, mycoplasmas), viruses, insects, and weed seeds. This eliminates the need to change soil in greenhouses, nursery beds, cold frames, hot beds, and other plant beds. Fumigants also have a place in treating foundation planting soil, tree sites, and in establishing turfgrass areas.

Soil can be sterilized (that is, disinfested or pasteurized) or fumigated easily using either heat or chemicals. Heat is usually the most effective in greenhouses since it kills all types of pests. Many chemicals are quite selective and kill only nematodes or fungi at normal application rates (Table 1).

SOIL FUMIGANTS--In recent years a number of chemicals have been formulated as volatile liquids, emulsifiable concentrates, wettable powders, granules, or gels to be applied in the soil. Most of these chemicals become gases and diffuse in soil to effect the kill. They are usually applied to soil several days or weeks before planting. Certain fumigants move through the soil slowly and require only a water "seal" after application. Other fast-acting and usually very toxic chemicals (e.g., methyl bromide and chloropicrin) must be confined with a gas-proof tarp made of polyethylene or other covering to retain the fumes.

The most useful fumigants to control nematodes plus the fungi and bacteria that cause wilts, damping-off, root and crown rots, and other diseases include chloropicrin ("tear gas"), methyl bromide, metam or SMDC, dazomet or DMTT, and MIT (Vorlex). These chemicals are often termed "biocides" because they are nonselective, killing essentially all organisms in the soil. All of these materials should be used *strictly* according to the manufacturer's recommendations. Observe all safety precautions listed on the label.

SOIL FUNGICIDES--These are applied as dusts or powders and blended into soil, soil sprays, and drenches, or as granules. Such fungicides control damping-off, seedling blights, crown and root rots, wilts, and other diseases. These include captan, benomyl, Botran, chloroneb, fenaminosulf, captafol, ferbam, etridiazol, Polyram, thiabendazole materials, PCNB, thiram, zineb, ziram, carboxin, folpet, and thiophanate compounds.

General Precautions and Suggestions

Soil condition. Soil must be loose and easily crumbled to a depth of at least 10 inches (the deeper the better) so it can be thoroughly penetrated by heat or chemicals. All lumps, trash, and clods should be broken up, and crop residues—especially large, diseased roots and stumps—should be removed or be well decomposed. Soil should be well mixed and in good seedbed condition when treated (moist enough to permit good seed germination—will just hold its shape when squeezed in the hand). Do *not* treat when soil is excessively dry, wet, or too cold (below 50° to 55° F).

Soil amendments. All soil amendments (e.g., manure, peat moss, compost, other humus material, sand, pea gravel) must be added before treating. It is especially important that organic matter be well decomposed. Packaged vermiculite, perlite, and soil mixes are normally sterile when purchased.

Treating tools. When using steam or methyl bromide, treat all tools (hoes, rakes, trowels, markers, shovels, spading forks), clay pots, flats, and rubber footware by laying them on top of the soil and under the gas-tight cover. Otherwise, dip or swab in a formaldehyde solution (1 pint in 5 gallons of water) after each use in contaminated soil and before using in treated soil. Boards or concrete at the bed edges should also be treated.

Avoid reinfestation of treated soil. Do *not* transplant seedlings, cuttings, or other plants from untreated or contaminated soil into disinfested soil. Soil is easily recontaminated by nonsterilized flats or pots, tools, and other equipment containing small bits of untreated soil, and contaminated water spattered by careless watering. Also, guard against disease-causing organisms in and on seed, cuttings, transplants, and other plant materials, unsterilized compost or manure, or gardener's hands and feet.

Wait before planting. After steaming, wait a day or two before seeding or planting. When chemicals are used, it may take 2 to 4 weeks to aerate soil before it is safe to plant. (See "Application and Remarks" under specific chemicals in Table 1. Soils high in organic matter or clay, excessively wet, or treated at low temperatures may retain the chemical at toxic levels for even longer periods.

Follow the manufacturer's directions on the label. A couple of days to a week after treating with a soil fumigant, work the soil at least once to a depth of several inches to allow the gas to escape. Control is best in light sandy-loam soils. Heavy clay and muck (peat) soils require 2 to 3 times the amount of fumigant used on sandy loams. Loose peat soils give little or no response to many soil fumigants, even at high rates of application. Excellent literature on calibration of equipment is available from fumigant suppliers. Fumigants are marketed as liquids, granules, and gases.

Other Precautions

1. *Temperature.* Most soil fumigants require that the soil temperature at the 6- to 8-inch depth be between 50° to 60° F. and 80° to 85° F. at the 3- to 5-inch level to permit optimum gas dispersion. Certain soil fumigants containing dichloropropenes can be used successfully at soil temperatures as low as 40° to 50° F.
2. *Time for treatment.* Late summer or early fall is usually the ideal time for chemical treatment of soil; crops have been harvested and soil temperatures are suitable for fumigation.
3. *Safety.* When handling soil fumigants follow these precautions:
   a. *Do not inhale fumes.* Handle fumigants only in open air and wear an approved respirator (or gas mask). Do *not* breathe the vapors. Chemicals are often irritating to the membranes of mouth, nose, and throat. If you inhale a fumigant, get to fresh air immediately and call a doctor. If breathing has stopped, give the patient artificial respiration. Keep the patient quiet and obtain medical attention as soon as possible.

   b. *Wear safety chemical worker's goggles* to protect the eyes. If eyes are accidentally contaminated, flush them with *flowing* water for at least 10 to 15 minutes and then consult a physician or Poison Treatment Center.

   c. *Do not spill chemicals on skin, clothing, or shoes.* If a spill occurs, wash skin promptly with plenty of soap or detergent and water. Remove affected clothing and shoes immediately. Clothes should be washed and shoes aired until all odor of fumigant has gone. The use of heavy polyethylene or neoprene for gloves, boot or shoe coverings, and a protective apron is strongly recommended.

   d. *Never* attempt to siphon fumigant or other pesticide by mouth suction or blow out clogged lines or nozzles, since these substances are highly corrosive to mucous membranes and swallowing the chemical may kill you. If a fumigant is accidentally swallowed, produce vomiting (take a tablespoonful of salt in a glass of warm water or drink soapy water). Repeat until the vomit fluid is clear. Then call a physician and keep the poison victim still and quiet.

   e. *Corrosion.* These materials are corrosive to certain metals, e.g., aluminum, copper, magnesium, galvanized zinc, and their alloys. Rinse application equipment with kerosene or fuel oil after use. Do *not* use water.

   f. *Proper storage.* Store fumigants in tightly closed, original labelled containers in a cool, dry, well-ventilated place away from food, feed, seeds, plants, fertilizers, drugs, and behind locked doors. Keep out of inhabited dwellings and away from heat and open flame. Avoid freezing.

   g. *Always follow manufacturer's directions carefully.* Note recommended dosage, interval to avoid excessive residues or injury, type of covering if needed, and method of application.

   h. *Do not damage plants.* Most fumigants, especially gaseous ones (e.g., metam or SMDC (Vapam), Dazomet or DMTT, D-D, EDB, MIT (Vorlex), chloropicrin, formaldehyde, and methyl bromide) *cannot be used* in a greenhouse or other confined area where living plants are present. Fumigants used outdoors should not be applied close to valuable plants, e.g., within 5 feet of shrubs or the drip line of trees. Growers should post warning signs when using dangerous chemicals in a greenhouse or other confined area.

Use of soil disinfestants in alkaline soils may cause a phosphorus deficiency in certain plants. In soils low in available phosphorus, work into the soil 10 pounds of superphosphate per 1,000 square feet before fumigation.

Fumigation may temporarily raise the level of ammonia nitrogen and soluble salts in the soil. This is most likely when heavy rates of fertilizer and fumigant are applied to soils that are cold, wet, acid, or high in organic matter. To avoid injury to plants, fertilize as indicated by a soil test made *after* fumigation. Ammonia injury and nitrate starvation are avoided by using only fertilizers containing nitrate nitrogen (at least 30% N) until after the crop is well established and the soil temperature is above 70° F. Liming highly acid soils (below pH 5.5) before fumigation stimulates nitrification and reduces the possibility of ammonia toxicity. Adequate amounts of calcium, magnesium, and phosphorus in the soil should be maintained, based on a soil test.

Other Soil Treatments (including Nematicides)

These chemicals are usually applied by licensed commercial applicators as a spray, granules, or soil drench for both soil and established turf. Unlike soil fumigants (Table 1), the active ingredient does not move through the soil as a gas but as a liquid in soil water. It generally does not require a waiting period between application and transplanting or seeding a crop. Soil temperature is also not a limiting factor.

Carefully follow all manufacturer's directions and precautions. With the exception of Diazinon, these highly toxic chemicals are solely or primarily for use *only by licensed or certified commercial applicators*, or persons working under their direct supervision, who are properly equipped and trained. They are NOT for home garden use.

1. *Aldicarb* (Temik). A highly toxic, long-lasting, granular, systemic combination insecticide-miticide-nematicide with some fungicidal activity for soil application to ornamental plants and some field crops. Contains 2-methyl-2-(methylthio) propionaldehyde-o-(methylcarbamyl)oxime as the active ingredient. *For commercial use only.*

2. *Carbofuran* (Furadan). A contact and systemic, long-lasting, broad-spectrum, soil and turf nematicide-insecticide-miticide that contains 2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate as the active ingredient. It is available as 10% granules (15-20 lb/A; 7-15-inch band on 40-inch rows) or as a flowable. Carbofuran is registered for use on some field crops, vegetables, shade trees, and pine seedlings. *For commercial use only.*

3. *Diazinon*, Science Diazinon, Spectracide, AG 500, Lawn Insecticide with Diazinon, and Sarolex. Available as granules, dust, or liquid. A broad-spectrum insecticide-nematicide for application to turf. Contains 0,0-diethyl o-(2-isopropyl-4-methyl-6-pyrimidinyl)phosphorothioate as the active ingredient. Diazinon is sold primarily as an insecticide, but is fairly effective against nematodes in sandy soils.

4. *Disulfoton* (Di-Syston, Disyston). A long-lasting, foliar, seed and soil, systemic insecticide-miticide-nematicide for use on certain field crops, vegetables, turfgrasses, flowers, and ornamental trees and shrubs. Available as granules

and as a liquid concentrate *for use only by commercial growers or professional applicators*. Disulfoton contains 0,0-diethyl S-[2-(ethylthio)ethyl]phosphorodithioate as the active ingredient.

5. *Ethoprop* (Mocap, ProTurf Nematicide)—A highly toxic, contact, granular, or liquid, long-lasting, broad-spectrum, soil and turfgrass nematicide-insecticide. It is registered for use on certain field crops, ornamentals, and turfgrasses. Ethoprop contains 10% or 15% 0-ethyl S,S-dipropylphosphorodithioate as the active ingredient. For soil, apply 1 to 8 gal/A before or at planting time (incorporate thoroughly) or as a post-plant band application. For turf, distribute evenly over the established area to be treated, and drench in immediately using at least one-half inch of water. Carefully follow all manufacturer's directions and precautions.

6. *Fenamiphos* (Nemacur). A long-lasting, contact and systemic, broad-spectrum, soil and turf nematicide *for commerical or professional use only*. Contains ethyl-4-(methylthio)-m-tolyl isopropylphosphoramidate or ethyl 3-methyl-4-(methylthio)phenyl(1-methylethyl) phosphoramidate as the active ingredient. Available as granules and as an emulsifiable concentrate. Useful on certain field and vegetable crops. Applied as outlined for ethoprop (above). Also used as a seed treatment.

7. *Fensulfothion* (Dasanit, Chemagro Dasanit Insecticide-Nematicide, Terracur P, and Dasanit Ornamental and Turf Nematicide). A highly toxic, long-lasting, primarily contact nematicide-insecticide for certain commercially grown turfgrasses, field crops, flowers, ornamental shrubs, foliage plants, and vegetables. Also used as a plant dip. Contains 0,0-diethyl 0-[4-(methylsulfinyl) phenyl] phosphorothioate as the active ingredient. Available as 15% granules and as a 63% liquid spray concentrate. Apply the same as for ethoprop (above); 1 to 3.3 gal/A of liquid concentrate or 20 to 184 lb/A of the granular product.

8. *Oxamyl* (Vydate). A liquid or granular systemic and contact nematicide-insecticide-miticide containing 24% methyl-N,N'-dimethyl-N-[(methylcarbamoyl)oxy]-1-thiooxamimidate as the active ingredient. Applied as a foliar spray on woody plants; preplant soil incorporation; soil drench; root, corm and bulb dip; and in transplant water for use on certain vegetables and ornamentals. *Not for use in home plantings.*

9. *Aldoxycarb* (Standak). A highly toxic, long-lasting, granular, systemic combination insecticide-nematicide-miticide which is a close relative of aldicarb (above) and used for many of the same purposes. It contains 2-methyl-2-(methyl sulfonyl) propanol-o-[(methylamino)carbonyl]oxime as the active ingredient. *For commercial use only.*

10. *Dichlofenthion* (Mobilawn VC-13 Nemacide). A residual nematicide-insecticide for application to soil or turfgrass. It is a 75% liquid concentrate that contains 0-2,4-dichlorophenyl o,o-diethyl phosphorothioate as the active ingredient.

11. *Terbufos* (Counter 15G). A systemic insecticide for control of nematodes on corn.

Table 1. Soil-disinfesting Chemicals--Materials, Brands, Controls, Application, and Remarks

TREATMENTS MATERIALS, BRANDS	CONTROLS	APPLICATION AND REMARKS
1. *Steam* Heat soil (6 inches deep or the coldest spot) to 180°-200° F (82°-93° C) for 30 min., or to 160° F (71° C) for 60 minutes.	All types of pests--fungi, most bacteria, nematodes, mycoplasmas, viruses, soil insects, mites, garden centipedes, and most weed seeds if moist.	Various methods are available: Pressure cooker (for small amounts), tank or vault, buried tile, perforated pipes on top of or in soil, or inverted-pan. Soil in benches or beds should be covered with a tarp. When steaming large quantities of soil, use a pressure between 15 and 100 pounds per square inch (psi).
Dry heat--Heat soil to 180° F (82° C) and keep at this temperature for 30 minutes.	All types of pests--the same as for Steam (above)	Place small quantities in an oven or use an electric soil pasteurizing box (e.g., Famco, Thermasoil).
2. *Multipurpose Chemicals* *Methyl Bromide*; Dowfume MC-2; Terr-O-Gas; Terr-O-Gel; Picride; Profume; Brom-O-Gas; Brom-O-Sol; Celfume; Meth-O-Gas; Nemaster. (Methyl bromide, usually with chloropicrin added.) Celfume-D and Rotox Gelled Soil Fumigant contain 70% methyl bromide and 28.7% EDB; Dowfume MC-33 and Terr-O-Gas 67 contain 67% methyl bromide and 33% chloropicrin. Trizone contains 60% methyl bromide, 30% chloropicrin and 9% propargyl-bromide.	Nematodes, grubs, garden centipedes, cutworms, wireworms, and other soil insects, weed seeds, damping-off, seedling blights, wilts, other soil-inhabiting disease-causing fungi, e.g., *Pythium, Fusarium, Phytophthora, Rhizoctonia, Sclerotinia, Verticillium*, actinomycetes.	Treatment is only for commercial applicators who are properly equipped. Compressed gas in aerosol cans, cylinders, or drums. Must apply with a special applicator under a gas-proof cover. A fumigation period of 1 to 2 days is needed. A 1- to 2-week wait is normally required between treating and planting. Good in coldframes, greenhouses, turf, nurseries, and outdoor beds. *Very poisonous*. Carefully follow all manufacturer's directions. To kill soil fungi use 3 to 4 pounds/100 sq ft; for other pests 1 to 2 lbs. Do *not* use before planting onions, garlic, celery, carnations, salvia, snapdragons, conifers, holly, and multiflora rose. Most formulations contain a small amount of chloropicrin (about 1 or 2%) as a warning agent. Tractor-mounted machines with chisel-type applicators are used for field-scale operations. This equipment simultaneouly lays a gas-proof cover. To disinfect tools, containers, and machinery, cover with a gas-proof cover and weight edges down. Apply 1 to 4 lbs/100 cubic feet. Leave cover in place for 2 to 3 days if the temperature is 50° to 59° F; 1 day if temperature is 60° F or above. A full-face gas mask fitted with a black canister must be worn during application and when cover is removed. Do *not* use around living plants.
Chloropicrin; Pic-Clor; Tri-clor; Chlor-O-Pic. (Tear gas or trichloronitromethane.) For combinations with methyl bromide see above; combinations with EDB include Terr-O-Cide 15,30,54-45,72-27; combinations with D-D include Terr-O-Cide 15-D, 30-D and 57/43/T.	Nematodes, damping-off, seedling blights, and other soil-inhabiting, disease-causing fungi and bacteria, weed seeds, and soil insects. Controls same range of pests as does methyl bromide (above). The best chemical for control of Verticillium wilt.	Treatment is only for commercial applicators who are properly equipped. Liquid in pressure cans or cylinders. Apply with special injection equipment in holes 6 to 8 inches deep, at 8- to 12-inch intervals. Inject chemical into each hole and close by stepping on the hole (33-50 gal/A for light soils; 41-77 gal/A for heavy soils). After treatment, apply gas-proof cover or sufficient water to soak upper inch of soil to seal in gas. Maintain water seal or cover for at least 3 days. Do not plant in treated soil until all traces (odor) of chloropicrin has gone (2 to 4 weeks). Use an approved chloropicrin full-face mask, canister, and polyethylene gloves while working. Carefully follow all manufacturer's directions. Do *not* use around living plants.
Methyl isothiocyanate or *MIT*: Vorlex Soil fumigant (20% methyl isothiocyanate and 80% chlorinated C_3 hydrocarbons including dichloropropenes.	Nematodes, soil insects including symphylans, germinating weed seeds, bacteria, damping-off and seedling blight fungi, *Verticillium*, and other soil-inhabit-	Apply like chloropicrin (above) but use chisel spacings of 6 to 8 inches and 7 to 60 gal/A. Pack treated soil and apply a light water seal or plastic cover. Leave soil undisturbed for at least 7 days. Then aerate (cultivate) to prevent soil crusting. Do *not* plant for 3 to 4 weeks or until all odor is gone. Higher rates and cold or heavy soils require

Table 1. (Continued)

TREATMENTS MATERIALS, BRANDS	*CONTROLS*	*APPLICATION AND REMARKS*
	ing, disease-causing fungi.	longer waiting periods (7 days for each 23 lb of active product). Carefully follow all manufacturer's directions.
Metam-sodium or *SMDC*; Stauffer Vapam Soil Fumigant; F & B Vapam; Metam-Fluid BASF; Sol-asan 500 (32.7% sodium N-methyl dithiocarbamate (anhydrous).)	Nematodes, soil-inhabiting and disease-causing fungi and bacteria, germinating weed seeds, and soil insects including garden centipedes; also a herbicide at higher rates of application.	Sprinkle diluted liquid uniformly over soil with sprinkling can, hose proportioner, sprayer, or meter into irrigation system. Or apply like chloropicrin (above) using 15-45 gal/A. Cover treated area with a tarp for 4 days after treating, or apply a water seal to upper inch of treated soil (15 to 20 gallons per 100 sq. ft). Do *not* treat more than 100 sq ft at a time before applying water seal. When top-treated soil has dried sufficiently, cultivate 1 to 2 inches deep. Do *not* plant until 3 to 4 weeks or more after treatment. Fall application is best. Do *not* use in greenhouses or close to where desirable plants are present.
Dazomet or *DMTT*; Mylone 85% WP, Dust-50; Crag Fungicide 974; Hopkins Mylone 50D; Crag Nemacide; Dazomet-Powder BASF; Basamid-Granular; Miller Mico-Fume 25-D (Mylone) (Tetrahydro 3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione).	Nematodes, soil fungi, certain weed seeds, and soil insects.	Apply as a preplant soil drench (12 to 50 gal/A), dust, wettable powder or granules using a sprinkling can, sprayer, or fertilizer spreader. Disc, rake, or cultivate (rototill) into soil. Used for seed and plant beds. Cover treated area with gas-proof plastic cover or apply water seal as for Metam-sodium (above). Wait 3 to 4 weeks before planting. Fall treatment is best. Fumes are toxic to growing plants; greenhouses must be empty. Follow all manufacturer's directions and precautions.
Formaldehyde (Formalin) DuPont Formaldehyde Solution, Parsons U.S.P. Formaldehyde. (Usually sold as a 37-40% solution in water and methanol.)	Damping-off, seedling blights, other soil-inhabiting and disease-causing fungi and bacteria, soil insects, and many soft or germinating weed seeds. Good disinfectant for tools, equipment, and storage areas. Also a seed disinfestant. Does NOT control nematodes.	Mix 3 tablespoons of formaldehyde in a cup of water and sprinkle over a bushel of soil (32 qts); 1 tablespoon in 1/2 cup of water treats a florist's flat of soil. Mix in very thoroughly with a shovel or hoe on a flat surface. Put treated soil in flats, pots, or leave in pile and cover with plastic, wet burlap, or canvas for 2 to 3 days. Drench soil in plant beds or seed flats. Use 1 cup in 3 gal of water. Apply slowly and evenly, 1/2-1-1/2 gal/sq ft, using a sprinkling can. Cover soil. After 2 to 4 days remove cover, work soil, and plant when all odor is gone. Never use in a greenhouse or where plants are growing; fumes are toxic to plants.
3. Chemicals Primarily for Nematode Control (Nematicides)		
EDB; Ethylene Dibromide; Celmide; EDB-85; Kop-Fume; Nephis; E-D-Bee; Soilbrom 40, 85 and 90; Ortho Ethylene Dibromide; Bromofume; Pestmaster Fumigant EDB-85 (1,2-dibromoethane). Terr-O-Cide 15 is a mixture of 40% EDB and 15% chloropicrin; Terr-O-Cide 30 contains 36% EDB and 30% chloropicrin.	Nematodes, wireworms, grubs, garden centipedes, and certain other soil-borne pests. Does little to control soil-borne fungi and bacteria.	Apply preplant, 6 to 8 inches deep at 10- to 12-inch intervals with a hand injector or special tractor-mounted equipment using 3 to 50 gal/A. Do *not* use around living plants or where onions, lilies, amaryllis, and other bromine-susceptible plants will be grown within 3 years. Wait 3 to 4 weeks or more before planting. EDB is recommended for fall treatment only. Fumes are toxic to plants; greenhouses and other enclosed areas must be empty. Carefully follow all manufacturer's directions.

Table 1. (Continued)

TREATMENTS MATERIALS, BRANDS	*CONTROLS*	*APPLICATION AND REMARKS*
1,3-D; D-D Soil Fumigant: Telone II; Stauffer DD Soil Fumigant; Ortho D-D Soil Fumigant; Nemafume (mixed dichloropropenes). Terr-O-Cide 15D is a mixture of 85% D-D and 15% chloropicrin. Terr-O-Cide 30D contains 70% D-D and 30% chloropicrin.	Nematodes, wireworms, garden centipedes, and other soil insects, weed seeds, and certain other soil-borne pests. Gives poor control of soil bacteria and fungi.	Apply preplant 6 to 8 inches under soil surface like EDB (above) at 10- to 12-inch intervals using 8-120 gallons per acre. Cover with a gas-proof plastic cover for 1 week. Do *not* plant until 3 to 6 weeks after treatment. Carefully follow all manufacturer's directions. Never use in a greenhouse or where plants are growing. Recommended for fall treatment only.
4. Chemicals Primarily for Fungus Control (Fungicides)		
Captan, etridiazol, thiram, Polyram, Banrot, fenaminosulf (Lesan), Polyram, zineb, ferbam, ziram, benomyl, thiabendazole, chloroneb. (See also under these names.)	Seed rot, damping-off, seedling blights, caused by fungi in greenhouse (cutting) benches, flats, hot beds, pots, cold frames, and flower beds.	Apply as dust or spray uniformly over loose, fairly dry soil. Cultivate thoroughly into top 2-1/2 to 4 inches of soil. Seed can be planted immediately after treatment. May also be applied as a post-plant soil spray or drench. Use about 1 pint to 1 quart of prepared mix per square foot. Repeat at 5- to 40-day intervals if disease persists. Check and follow all label directions and precautions.
PCNB or quintozene; Terraclor; Brassicol; Fungiclor. (Pentachloronitrobenzene.)	PCNB controls certain disease-causing fungi, e.g., *Rhizoctonia, Botrytis, Sclerotinia, Sclerotium.* (Etridiazol and fenaminosulf control water molds.)	Various application methods including suspension in transplant water, soil surface sprays or dusts, and dry mixing into upper 2 to 6 inches of soil. Sometimes mixed with etridiazol, fenaminosulf (Lesan), captan, ferbam, captafol, benomyl, or chloroneb. Thorough mixing with soil is essential. Follow manufacturer's directions regarding rates and methods of application.

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1983 Condensed Plant Disease Management Suggestions for Field Crops

B.J. Jacobsen, M.C. Shurtleff, and H.W. Kirby

The best way to ensure the success of a disease-management program is to adapt it according to the diseases expected and to use integrated disease-control measures. Among these measures are the use of resistant varieties, crop rotations, fungicides, nematicides, and suggested agronomic practices. The success of any one or all of these measures may depend on how carefully you scout your crops. Because periodic crop scouting increases the likelihood that you will apply disease controls properly, it can help prevent both loss through disease and unnecessary use of pesticides.

Specific information for the control of the important diseases of corn, soybeans, wheat, and alfalfa can be found in the following issues of *Report on Plant Diseases**:

No. 123—"Winter Wheat Disease Management Program"
No. 212—"Illinois Corn Disease Management Program"
No. 308—"Alfalfa Disease Management Program"
No. 507—"Illinois Soybean Disease Management Program"
No. 1001—"Seed Treatments for Field Crops"

Federal and State Laws Restricting Pesticide Application

The U.S. Environmental Protection Agency (EPA) is classifying pesticides for "general" or "restricted" use. Anyone applying a restricted-use pesticide, whether "commercial" or "private," must be certified.

Commercial applicators include not only persons applying restricted-use pesticides for hire but also governmental personnel, chemical-company representatives, and others involved in demonstrational, regulatory, and public-health pest control. Certification as a commercial applicator requires passing a written examination administered either by the Illinois Department of Agriculture or the Illinois Department of Public Health.

Private applicators who use restricted-use pesticides "for the purpose of producing any agricultural commodity on property owned or rented by him or as exchange labor

*These and other issues of *Reports on Plant Diseases* are available from the Department of Plant Pathology, N533 Turner Hall, 1102 S. Goodwin, University of Illinois, Urbana, IL 61801 at a cost of fifteen cents each.

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(no compensation) on the property of another must also be certified, either by attending an educational training program or by passing an examination."

Educational training programs for farmers (private applicators) and commercial pesticide applicators are conducted by the Illinois Cooperative Extension Service to prepare persons for certification. The actual certification and the issuing of permits or licenses are handled by the Illinois State Department of Agriculture.

When this publication was prepared, only a few of the fungicides and nematicides listed in Tables 1 and 2 had been classified, but additional classifications are expected before the 1983 growing season. Your county Extension adviser has additional information on pesticide restrictions and certification requirements.

Always Read the Pesticide Label Before Use

The chemical names used in this circular may be unfamiliar to you. They are the common, coined chemical names and are not capitalized (for example, benomyl). Trade names are capitalized (for example, Benlate). Table 3 lists the common and trade names of fungicides and nematicides.

Fungicide Application

At present, aircraft are the best vehicles for applying fungicides to agronomic crops. Some aircraft may not be equipped or calibrated to do this job. It is therefore important to select an aerial applicator who is familiar with disease control and whose aircraft has been properly calibrated for uniform, thorough coverage of all aboveground plant parts. With the equipment now available, a reasonable job of applying fungicides requires 5 gallons of water carrier per acre. Superior coverage may be obtained with more water, but the cost may be prohibitive. Conversely, a lower volume (under 3 to 4 gallons per acre) gives correspondingly poorer control. Five gallons of water can be applied uniformly using approximately 30 to 70 properly spaced nozzles, depending on the aircraft. The nozzles should be D-8 to D-12, hollow cone, with No. 45 or No. 46 cores. The final decision on nozzle number, size, swath width, and placement depends on the air speed, pressure, and volume desired. Droplet size is also important. Ideally, droplets should be 200 to 400 microns in size for thorough and uniform coverage.

Adjuvants

When it is compatible with the product label, add a spray adjuvant (surfactant) to the spray mix. Some commonly available surfactants are: Colloidal Products X-77 (liquid, nonionic) Spreader; Colloidal Products Multi-Film L (liquid); Colloidal Products Spray Modifier (liquid, nonionic) spreader sticker; Miller Nu-film-17 liquid spreader sticker; Miller Nu-film-P liquid spreader sticker; Allied Chemical Plyac (liquid) Non Ionic Spreader-Sticker; Rohm & Haas Triton B-1956 (liquid, nonionic) spreader sticker; Triton C-57, spreader-binder; and DuPont Spreader Sticker (liquid) spreader-sticker.

Adjuvants are suggested for use when you spray corn or small grains.

Nematicide Application

Granular nematicides/insecticides registered for use on corn and soybeans may be used as infurrow or band treatments, depending on the product label. In general, band applications have given more consistent control than have infurrow applications. Follow the manufacturer's suggestions on incorporation.

Table 1. Condensed Disease-Control Recommendations for Field Crops

Crops and diseases	Fungicide/nematicide	Comments
Alfalfa		
Bacterial wilt, Phytophthora root rot		Resistance should be strongly considered when choosing a variety.
Leafspots, spring blackstem, and anthracnose		Cut forage in a timely manner to maximize yields and minimize leaf loss. Grow adapted resistant varieties.
Crown and root rots		Maintain proper fertility and soil pH. Avoid cutting or grazing during the last 5 to 6 weeks of the growing season. Control insect pests.
Verticillium wilt		This disease has been identified in northwestern Illinois and found in Wisconsin. Varieties with reported resistance include Apollo II, Trumpeter, WL316, Decathelon, and Funks G 2640. This disease will only be a problem in stands more than 3 years old.
Seed rots and seedling blights	Captan, captan + zineb, thiram	Seed treatment is not usually necessary with high-quality seed.
Sclerotinia white mold		Spring planting, deep and clean plowing, using 3- to 4-year rotations with nonlegume crops, and avoiding excessively lush growth may help. Chemical controls are not available. The variety Cimarron is reported to be moderately resistant.
Barley		
Seed rot, seedling blight, loose smut, and semiloose smut	Carboxin + thiram, carboxin (planter-box) plus maneb + HCB or captan + HCB (planter-box), captan + carboxin	Seed treatment is strongly suggested. Carboxin is required for loose smut control.
Helminthosporium leaf blight, Septoria leaf blotch	mancozeb	Apply when disease conditions warrant. Apply when plants are in the late tillering to jointing stage; repeat at 7- to 10-day intervals. Do not make more than 3 applications. Do not apply within 26 days of harvest.

Table 1. (Continued)

Crops and diseases	Fungicide/nematicide	Comments
Barley (cont.)		
Barley yellow dwarf virus		Plant winter barley after the fly-free date and spring barley as early as possible.
Clover		
Anthracnose diseases		Grow adapted resistant varieties.
Crown and root rots		Same as for alfalfa.
Seed rots and seedling blights		Same as for alfalfa.
Corn		
Seed rots and seedling blights	Captan, captan + maneb, captan + zineb, captan + HCB + maneb, carboxin, carboxin + thiram, mancozeb, maneb, PCNB + etridiazol, TCMTB, thiram, thiram + maneb	Sow injury-free plump seed in soils at 50°F. or above. Prepare the seed bed properly and place herbicide, fertilizer, insecticide, and seed correctly. Note: Fungicide plus insecticide seed treatments are commonly used.
Stewart's disease		Plant resistant hybrids and use insecticides to control flea beetles when necessary.
Goss's bacterial wilt and leaf blight		Plant resistant hybrids. Clean plowdown and 2-year crop rotations also give control. Use clean plowdown only where erosion will not be a problem.
Helminthosporium leaf blights northern leaf blight northern leaf spot southern leaf blight helminthosporium leaf blight Common rust and southern rust	Zineb, mancozeb	Plant resistant hybrids. Apply 2 to 4 sprays at 10-day intervals starting when disease *first* appears. Fungicide control is justified only when significant disease occurs before 2 weeks after tasseling. Use a spreader-sticker. Fungicide applications are generally economically feasible only in seed-production fields. Do not apply within 40 days of harvest. Do not feed fodder or forage to livestock.

Table 1. (Continued)

Crops and diseases	Fungicide/nematicide	Comments
Corn (cont.)		
Physoderma brown spot, yellow leaf blight, eyespot, anthracnose, crazy top, sorghum downy mildew, and virus diseases		Plant resistant or tolerant hybrids. Control Johnsongrass to reduce over-wintering source of MDMV and MCDV. Control wild cane to reduce sorghum downy mildew inoculum.
Stalk rots *Diplodia* charcoal *Gibberella* *Nigrospora* *Fusarium* anthracnose		Plant hybrids with good stalk rot resistance and stalk strength. The use of nitripyrin (N-Serve) may be helpful where nitrogen loss is expected. Maintain adequate phosphorus and potassium fertility for the rate of nitrogen used. Control corn borers and corn rootworms. Scout fields at 30- to 40-percent moisture for lodging potential. Walk a zig-zag pattern through the field pushing random plants about 5 inches from the vertical. If more than 10 to 15 percent lodge, schedule the field for early harvest.
Storage molds *Penicillium* spp. *Aspergillus* spp.	Propionic acid, isobutyric acid, acetic acid, or mixtures of these	Grain treated with an acid grain preservative can be used *only* for animal feed. Store undamaged corn at 15 to 15.5 percent moisture from fall until spring, then dry to 13 percent for long-term storage. Grain damaged by field molds, insects, etc., should be dried to 13 to 13.5 percent moisture at harvest. Watch stored grain for heating, a musty odor, crusting, or other signs of storage mold activity. Control stored grain insects.

Table 1. (Continued)

Crops and diseases	Fungicide/nematicide	Comments
Corn (cont.)		
Nematodes root-lesion needle dagger spiral lance stubby-root sting stunt	Carbofuran, ethoprop, terbufos	Use nematicidal rates of these materials where soil tests indicate economic populations of nematodes. Use crop rotation where appropriate.
Oats		
Seed rots and seedling blights, loose smut and covered smut	Captan + HCB, captan + HCB + maneb, carboxin, carboxin + thiram, HCB + maneb, PCNB, TCMTB, captan + carboxin	Seed treatment is strongly suggested for control of smut diseases.
Helminthosporium leaf spot, Septoria leaf blotch	Mancozeb	Spray when disease is present and weather conditions favor disease development. Start applications at tillering to jointing stage. Make a second application 10 days later. A third application is permissible but may be uneconomical. Do not apply within 26 days of harvest.
Barley yellow dwarf		Grow resistant varieties. Plant susceptible varieties as early in the spring as possible.
Crown rust		Plant resistant varieties. Fungicides applied for *Septoria* and *Helminthosporium* will also aid in crown-rust control.

Table 1. (Continued)

Crops and diseases	Fungicide/nematicide	Comments
Sorghum		
Seed rots, seedling blights, and smuts	Captan, captan + thiram, captan + zineb, captan + PCNB, HCB + maneb, PCNB + etridiazol, thiram	Fungicide seed treatment is strongly suggested.
Other diseases		Plant resistant or tolerant hybrids. Diseases other than the smuts have not been important in Illinois.
Nematodes	Aldicarb	
Soybeans		
Seed rots and seedling blights	Captan, captan + maneb, captan + thiram, captan + zineb, captan + HCB + maneb, captan + PCNB, HCB + maneb, mancozeb, maneb, PCNB + etridiazol, TCMTB, thiram, Vitavax + thiram, carboxin + captan	Plant high-quality seed germinating about 70 to 80 percent in a cold germination test. Seed treatment is recommended where: (1) seed of poor quality due to fungal infection must be planted; (2) delays in emergence are anticipated; (3) seed is planted to produce seed; and (4) reduced seeding rates are used.
Brown stem rot		Rotate, using 2 years of corn in fields where disease has been damaging. The varieties BSR 301 and BSR 201 have moderate resistance.
Pod and stem blight, anthracnose, stem canker, Septoria brown spot, Cercospora leaf blight, and purple seed stain	Benomyl, thiabendazole, thiophanate-methyl, chlorothalonil	Suggested for use where disease conditions warrant (see Table 2). Two applications are suggested for maximum yield and seed quality. Benomyl and thiabendazole have 24c labels for a single late application at higher labeled rates for improved seed quality.
Soybean cyst nematode	Aldicarb, carbofuran, fenamiphos	Nematicides are suggested where (1) resistant varieties cannot be used and (2) crop rotations are not possible. Aldicarb has given the most consistent control in Illinois; applied in-furrow, it has given control equal to higher rates applied as bands. Both aldicarb and carbofuran can be applied in-furrow.

Table 1. (Continued)

Crops and diseases	Fungicide/nematicide	Comments
Soybeans (cont.)		
Phytophthora root rot		Plant resistant or tolerant varieties. *Note:* Several races of the Phytophthora fungus exist in Illinois.
Sclerotinia white mold		Rotate with nonlegume crops. Plant moderately resistant varieties in fields where disease has been present before.
Wheat		
Seed rots, seedling blights, loose smut, and bunt (stinking smut)	Carboxin + thiram, carboxin (planter-box) plus maneb + HCB, or captan + carboxin	Seed treatment is strongly suggested. Higher labeled rates of carboxin are required for bunt control. Only carboxin controls loose smut.
Leaf rust, Septoria leaf blotch, Septoria glume blotch, Helminthosporium leaf blight, and stem rust	Mancozeb, zineb	Apply fungicide when disease conditions warrant. Begin applications at the jointing stage and repeat at 7-day intervals. Do not make more than 3 applications. Do not apply within 26 days of harvest. Plant resistant varieties.
Powdery mildew		Plant resistant varieties. Check with Extension adviser for chemical control recommendations.
Virus diseases wheat streak mosaic wheat soil-borne mosaic barley yellow dwarf mosaic wheat spindle streak mosaic		Plant resistant or tolerant varieties. Plant after the fly-free date. Control volunteer wheat in and around production fields.
Take-all		Plant after the fly-free date. Use ammonium form of nitrogen fertilizer. The varieties Caldwell and Sullivan are reported to be moderately resistant to take-all. Use crop rotations of 2 to 3 years between wheat crops where possible.

Table 2. Checklist To Determine Whether Fungicide Application Should Be Made to Soybeans

Risk factors	Point value if the answer is yes
Rainfall, dew, and humidity up to early bloom and pod set are:	
Below normal.	0
Normal.	2
Above normal.	4
Soybeans grown in the field last year.	2 to 3
Chisel-plow, disk, or no-till.	1
Pycnidia (black specks) visible on fallen petioles and Septoria brown spot obvious on the lower leaves.	2
Early-maturing variety (not full-season)	1 to 2
Soybeans to be used or sold for seed	3
Yield potential better than 35 bushels per acre	2
Seed quality at planting time is less than 85 percent germination in a warm test.	1
Other conditions that favor disease development (weather forecast with a 30-day period of greater than normal rainfall and a field history of disease)	1 to 3

Note: If the total point value is 12 or more for seed-production fields, or over 15 for grain-production fields, application will probably mean increased yields and higher seed quality.

Table 3. Pesticide Classification, Common Names, and Some Trade Names of Pesticides Mentioned in this Report on Plant Diseases

Common name	Trade name	Use classification
aldicarb	Temik	Unclassified
benomyl	Benlate	Unclassified
captan	Captan, Orthocide, and many others	Unclassified
captan + HCB	Ortho Seed Treatment, Orthocide-HCB, Miller's HCB 4 Flowable, and many others	Unclassified
captan + HCB + maneb	Res Q	Unclassified
captan + PCNB	Stauffer Captan-Terraclor 10-10 and 30-30 Seed Protectant, Orthocide PCNB 10-20 Dust, and many others	Unclassified
captan + zineb	Staples Dithane Seed Treatment Dust	Unclassified
captan + carboxin	Orthocide-Vitavax 20-20, Vitavax-Captan HBM-25	Unclassified
carbofuran	Furadan	All concentrate suspensions and WP formulations $\geq$ 40%--restricted. Granular formulations--unclassified.
carboxin	Vitavax, Vitavax 25 DB	Unclassified
carboxin + thiram	Vitavax 200, Vitavax-T	Unclassified
chlorothalonil	Bravo 500	Unclassified
ethoprop	Mocap	EC formulations—restricted Granular formulations—unclassified
etridiazol	Terrazole	Unclassified
maneb	Manzate D, Manzate Maneb Fungicide, Dithane M22, M22 Special, and many others	Unclassified
maneb+HCB	Granox NM, Granox Flowable	Unclassified
mancozeb	Manzate 200, Dithane M45	Unclassified
PCNB	Terraclor	Unclassified
PCNB + etridiazol	Terraclor Super X Terra-Coat L21, L205, and SD205 Seed Treatment	Unclassified
TCMTB	Busan, Cover-Up, and Thiogem	Unclassified
terbufos	Counter	Unclassified
thiabendazole	Mertect 340F	Unclassified
thiophanate-methyl	Topsin M	Unclassified
thiram	Arasan 50-Red Thiram and many others	Unclassified
zineb	Dithane Z-78	Unclassified

A more complete list of trade names than those in Table 3 can be found in *Report on Plant Diseases* No. 1001, "Seed Treatments for Field Crops," and No. 1002, "Fungicides, Disinfectants, Grain Preservatives, Surfactants, and Soil-Disinfesting Chemicals." These publications are available from the Department of Plant Pathology, N-533 Turner Hall, University of Illinois, 1102 S. Goodwin, Urbana, IL 61801.

Disease Reactions of Field Crop Varieties Recommended for Illinois

Disease reactions may vary from one locality to another and from year to year, depending on what physiologic races of the pathogens are present. For the latest information on suggested crop varieties, consult your county Extension adviser or the Department of Agronomy, University of Illinois at Urbana-Champaign 61801.

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Barley

	Recommended area of state[a]	Stem rust	Leaf rust	Loose smut	Covered smuts	Septoria	Powdery mildew	Barley yellow dwarf	Barley stripe mosaic	Spot blotch	Net blotch	Helminthosporium stripe	Scald
Spring													
Larker	N	MR[b]	S	S	S	S	S	MS	S	S	MS		S
Manker	N	MR	S	S	S	S	S	MS	S	MR	MR		S
Winter													
Barsoy	C,S	MS	S	S			MR	S	S		MS	S	S
Paoli	C,S	MS	MS	MS			MR	S	S		MR	MR	MR
Pike	C,S	MS	S	S			MR	S	S		MR	MR	S

[a]Area of Illinois where variety is recommended: N = northern; C = central; and S = southern. [b]Average disease reaction: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; VS = very susceptible; Blank = no information.

Oats

	Recommended area of state[a]	Stem rust	Crown rust	Smuts	Barley yellow dwarf	Septoria
Spring						
Clintford	N,C	S[b]	VS	R	MS	MS
Dal	N	MS	MR	MR	MS	MS
Froker	N	MR	MS	S[c]	S	MR
Lang	N,C,S	MS	S	MS[c]	MR	MS
Larry	N,C,S	MS	S	MS	MR	MS
Noble	N,C,S	MS	S	R	MR	MS
Ogle	N,C,	MS	S	MS	MR	MS
Otee	N,C,S	MS	S	MS	R	MS
Wright	N	MS	S	MS[c]	MS	MS
Winter						
Compact	S	S	S	MR	S	MS
Norline	S	S	S	MR	MS	MS
Walken	S	S	S	MR	S	MS

[a]Area of Illinois where variety is recommended: N = northern; C = central; and S = southern.
[b]Average disease reaction: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; VS = very susceptible; Blank = no information.
[c]Susceptible to new races of smut fungi.

Red Clover

	Recom-mended area of state[a]	Powdery mildew	Northern anthracnose	Southern anthracnose	Viruses
Arlington	N,C,S	R	R[b]		MR
E-688	C,S	R	T	R	
Florex	N	R	R		R
Florie	N,C,S	R	R	R	R
Ruby	N,C,S	R	R	T	
Kenland	C,S	S	S	R	S
Kenstar	C,S	S	S	R	MR
Lakeland	N	R	R	S	MR
Redland	C,S	R	MR	S	S
Redman	N,C,S	S	R	MR	S

[a]Area of Illinois where variety is recommended: N = northern; C = central; and S = southern.
[b]Average disease reaction: R = resistant; MR = moderately resistant; T = tolerant; S = susceptible; Blank = no information.

*Wheat**

	(Type)	Recommended area of state[a]	Stem rust	Leaf rust	Loose smut	Septoria	Powdery mildew	Soil-borne mosaic	Barley yellow dwarf	Spot blotch	Pyrenophora	Wheat streak mosaic	False black chaff
Spring													
Era		N	R[b]	S[c]	MR	MS	MS			MR	MS		
Olaf		N	MR	MR	S								
Winter	*(Type)*												
Abe	(Soft)	N,C,S	R	S[c]	MS	S	MS	R	MS				R
Argee	(Soft)	N	R	S	MR		MR	R	MR				
Arthur	(Soft)	N,C,S	R	S[c]	MS	S	MS	R	MS				R
Arthur 71	(Soft)	N,C,S	R	S[c]	MS	MS	MS	R	MS				R
Auburn	(Soft)	N,C,S	R	R	MR	R	MR	R	MS				
Beau	(Soft)	N,C,S	R	MS	MS	MR	MS	R	MS				R
Caldwell[d]	(Soft)	N,C,S	R	MR	MR	MS	MR	MR	MR				
Centurk	(Hard)	N,C	MR	MS	MR	S	S	MS	MR		MR	S	
Hart	(Soft)	N,C,S	S	S[c]	R	MR	VS	R	MR				
Oasis	(Soft)	N,C,S	R	S[c]	MS	MR	MS	R	MS				R
Parker	(Hard)	N,C	S	MR	MS	MS	S	S	MS				MR
Pike	(Soft)	N,C,S	S	S	MR	MS	S	MR	MR				
Roland	(Soft)	C,S	R	S[c]	MS	S	MS	R	MS			MS	
Roy	(Soft)	S	S	MS			MR	R	MR				
Scotty	(Soft)	C,S	R	MR		MR	R	R	MS				
Sullivan[d]	(Soft)	N,C,S	R	MR[c]	MR	MR	MS	R	MS				R
Tyler	(Soft)	S	S	S			R	R	MR				

*Note: Several private varieties have high yield potentials and are widely planted. Growers should contact seed company representatives for information on disease resistance.

[a]Area of Illinois where variety is recommended: N = northern; C = central; and S = southern.

[b]Average disease reaction: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; Blank = no information or disease is not important.

[c]Susceptible to new races that are virulent on *Lr* 9 and very common throughout the central United States in 1981 and 1982. Era is susceptible to nearly all leaf rust races as a seedling but has adult plant resistance that normally prevents leaf rust development on the flag leaf.

[d]Moderate resistance to Take-all.

*Soybeans**

	Suggested area of the state[a]	Phytophthora rot[c]	Bacterial pustule	Powdery mildew	Pod and stem blight	Soybean cyst nematode	Purple seed stain	Frogeye leaf spot	Downy mildew	Sclerotinia white mold
Amsoy 71	N,C	R	S	VS	S	S	VS	S-2	S	S
Beeson	N,C	R	S	MS	MS	S	S	R-1,2	MS	S
Beeson 80	N	R-1-3,7-9	S	MS	S	S	S	R-1,2	S	
Bonus	S	R	S	S	S	S	S	S-2	VS	S
Calland	C,S	R	S	R	S	S	S	S-2	S	S
Century	N,C	R-1,2	S		S	S	S	S-2	MS	S
Clark 63	S	R	R	MR	S	S	S	R-1,S-2	S	S
Corsoy	N,C	VS	S	VS	S	S	S	S-2	MS	MR
Corsoy 79	N,C	R-1-3,7-9	S	VS	S	S	S	S-2	MS	
Crawford	S	S	S		S	S	MR	S-2	S	
Cumberland	C,S	MS	R		MR	S	S	R-1,2	MS	
Cutler 71	S	R	S	R	S	S	S	R-1,2	S	
Dare	S	S	R		MS	S	S	R-1,2	MR	
DeSoto	C,S	S	S		S	S	S	S-2	S	S
Dyer	S		R		S	R-3				
Elf	C,S	S	R	S		S	S	MR-2	S	VS
Essex	S	S	R	MR	S	S	MS	S-2	MS	
Fayette	C,S	S	R		S	R-3,4	S	S		
Forrest[e]	S	MR	R			R-3				
Franklin	S	R	R		S	R-3	S		S	S
Gnome	N,C	S	R		S	S				S
Harcor	N	R-1,2	S		S	S		S-2		S
Hark	N	S	S	VS	S	S	S	S-2	S	
Hobbit	C	S	R							
Hodgson 78	N	R-1,2			S	S	S	S-2		MR
Lawrence	S	S	R			S				
Mack	S	R	R			R-3				
Nebsoy	N,C	R-1,2	S		MR	S		S-2		S
Oakland	C,S	R-1,2	S	R	MR	S	S	S-2	MS	
Pella	C,S	R-1,2	S		S	S	S	S-2	S	S
Rampage	N	S	S	R	S	S	S	R-1,S-2	S	
Union	S	R	R	R	MS	S	S	S-2	R	MR
Wayne	C,S	MS	R	MR	S	S	S	R-1,MR-2	VS	MR
Wells	N,C	R	S	VS	S	S	S	R-2	MS	
Wells II	N,C	R-1-3,6-9	S	VS	S	S	S	R-2	MS	
Will	C,S	S	R		MS	S	S	S	S	
Williams	C,S	MS	R	MS	MS	S	S	S-2	VS	MR
Williams 79	C,S	R-1-3,7-9	R	MS	MS	S	S	S-2	VS	
Williams 82	C,S	R-1-9	R			S	S	S-2	S	
Woodworth	C,S	MS	R	MR	MS	S	S	S-2	VS	S
Nathan[f]	S					R-3,4				
Pixie	S	S			S	S	S			S
Sprite	S	S			S	S	S			S

*Growers should contact individual seed companies for information on disease resistance of private varieties.

[a]Area of Illinois where variety is suggested: N = northern; C = central; S = southern.

[b]Average disease reaction: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; VS = very susceptible; Blank = no information.

[c]Races 1 and 2, except Mack races 1, 2, 3, 6, 7, 8, and 9.

[d]S-1,2 or R-1,2 etc.: Susceptible (S) or Resistant (R) to the pathogens indicated by the race numbers.

[e]Forrest is also highly resistant to wildfire, target spot, reniform nematode, and root-knot nematode.

[f]Nathan is also resistant to root-knot nematode.

Alfalfa

	Verticillium wilt	Bacterial wilt[a]	Common leaf spot	Lepto leaf spot	Spring black stem	Anthracnose	Phytophthora root rot	Winter hardiness[b]
Advantage		R				MR	R	MH
Agate		VR	R	MS	MS	MS	R	VH
Americana		MR	R			S	S	MH
Answer		R				MR	VR	MH
Apollo		R	MR	MS	MS	MS	R	H
Apollo II	MR	R				MR	R	H
Arc		MS	MS	MS	S	R	S	MH
Armor		R				MR	R	MH
Atlas		VR	MR			MR	S	H
A-9			R					H
A-24		S	R	S	MS	S	S	MH
A-37		R	MS					H
A-38		R				MS	MS	MH
A-53		MR						
A-54		MR	MR					
A-59		MR	MS	S	MR	MS	S	H
A-67			R					
Baker		R	MR			MS	S	H
Blazer		R				S	R	
Cimarron		MR	MR			R	R	MH
Citation		R	MS	MS		S	S	H
Conquest		R						
Dawson		MR	MS	S	MS		S	H
Defender		R				MR	MR	MH
DeKalb Brand 120		R					R	
DeKalb Brand 130		R				MR	S	MH
Discovery		R	MS				S	H
Duke		R				MR	R	MH
Epic		R				S	R	
Expo		R				MR	R	MH
Futura		R				MR	MR	H
Gladiator		VR	MR	MS		MS	S	MH
Glory		R	R					H
G-2815		R				MR	MS	MH
G-7730		R				MS	R	
Haymor		MS	MS	S	S	MS	S	MH
Hi-phy		R					R	
Honeoye		MR	MS	MS	MS	S	S	H
Kanza		R					S	MH
Magnum		R					MR	
Marathon		MR	MS	MS		S	S	MH
Mercury		R				MR	R	H
Olympic		R	MR			R	S	H

	Verticillium wilt	Bacterial wilt	Common leaf spot	Lepto leaf spot	Spring black stem	Anthracnose	Phytophthora root rot	Winter hardiness
Pacer		R	MR	MR	MS	S	MS	H
Peak		R				MS	R	
Perry		R				MR	S	H
Phytor		R	MR				R	H
Pioneer Brand 520		R	MS	MS	MS	MS	S	H
Pioneer Brand 521		R	MS	MS	MS	MS	S	H
Pioneer Brand 524		VR	MS			S	S	H
Pioneer Brand 530		R	R	MS	MS	MS	S	MH
Pioneer Brand 531		R				MS	S	
Pioneer Brand 532		R				MS	S	
Pioneer Brand 545		R					MR	
Polar I		R	MR	MR	MS		MS	H
Raidor		R				MR	S	MH
Riley		VR				R	S	MH
Saranac		MR	MR	MS	MS	S	VS	H
Saranac AR		MR	MR	MS	MS	R	S	H
Spredor 2		R				S	S	H
Sunrise		R						MH
Tempo		MR	MR	MS	MS	S	S	H
Thunder		R				MR	R	H
Trident		R					VR	H
Trumpeter	MR	MR				R	S	H
Valor		R	MS	MR	MR	MS	S	H
Vancor		R				R	MR	H
Vangard		MR	MS	MS	S	MR	S	MH
Vernal		R	MS	MS	MS	S	S	H
Voris A-77		VR				R	MS	H
Weevlchek		VR	MR	MS	MS	S	S	H
WL-215		R	MS	MS	MS	S	MS	H
WL-219		R	MR	MS	MS	MS	MS	H
WL-220		R	R			MS	R	H
WL-307		MR	MR	MR	S	MS	S	H
WL-309		MR	MS	MS	MS	MS	S	H
WL-311		R	MS	MS	MS	MR	MS	H
WL-312		R				MR	MR	H
WL-313		R				MR	S	H
WL-316	R	MR				R	S	H
WL-318		MR	MS	MS	MS	MR	MR	MH
Yukon		R	MR		R		S	H

[a]Average disease reaction: VR = very resistant; R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; Blank = no information.
[b]Winter hardiness, based primarily on autumn growth ratings: VH = very hardy; H = hardy; MH = moderately hardy; MS = winter hardiness is questionable.

	Recommended area of state[a]	Brown leaf spot (blight)	Bacterial blights	Leaf scald	Rust	Seedling disease complex	Northern leaf blight	Anthracnose
Bromegrass, smooth								
Barton	N,C,S					MS		
Baylor	N,C,S	R[b]	MS	MS				
FS Beacon	N,C,S					MS		
Blair	N,C,S	R	MS	MS		MS		
Lincoln	N,C,S	MS	MS	MS		MS		
Southland	S	S	MS	MS				
Orchardgrass								
Able	N,C,S							
Boone	S	MS			MS			
Comet	N,C							
Dart	N,C,S				MS			
Dayton	N	MS			MS			
Hallmark	N,C	MS			MS			
Ina	S							
Jackson	N,S							
Napier	N,C,S	MS			S			
Potomac	N,C	MS			S			
Sudangrass								
Piper	N,C,S						MR	MS
Tall fescue								
Alta	N,C,S				MR			
Fawn	N,C,S				MR			
Kenhy	N,C,S				MR			
Kentucky 31	N,C,S				MR			
Kenwell	N,C,S				MR			
Timothy								
Clair	N,C,S							
Climax	N,C,S							
Itasca	C							
FS 954	N,C							
FS 955	N,C,S							
Pronto	C							
Timfor	N,C,S							
Toro	N,C							
Verdant	C							
Reed canarygrass								
Flare	N,C							
Rise	N,C,S							
Vantage	N,C,S							

[a]Area of Illinois where variety is recommended: N = northern; C = central; and S = southern.

[b]Average disease reaction: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; VS = very susceptible; Blank = no information.

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Seed Treatments for Field Crops

M.C. Shurtleff, B.J. Jacobsen, and H. W. Kirby

Fungicide seed treatment is inexpensive crop insurance against a number of diseases that impair stands, reduce yields, and lower grain quality. Seed treatment is especially valuable during cold, wet weather in protecting germinating seed and young seedlings against seed- and soil-borne fungi that cause seed decay and seedling blights (damping-off). Proper seed treatment controls certain smut fungi of cereals and forage grasses that infect the seed and young seedlings. Fungicide seed treatment is effective in controlling the seed-borne fungi that cause the seedling stage of scab of grasses and small grains, anthracnose, seed-borne root and crown (foot) rots, Helminthosporium stripe and net blotch of barley, spot blotch of small grains, and various seed-borne fungi that cause leaf spots and blotches.

It is usually best to custom-treat at elevators, seed and feed houses, or processing plants *after* the seed is cleaned. Thorough cleaning removes weed seeds, smut "balls" and particles, bits of chaff or straw, and lightweight kernels that may be infected, as well as other undesirable impurities.

Seeds are treated by a fungicide formulated as a dust, wettable powder, flowable, or liquid. The fungicide may be applied to seed as a dust or liquid by using a revolving barrel or oil-drum treater or by adding it to the drill or planter box. Manual mixing with the seed in the drill box immediately before sowing reduces the possibility of treated grain being used for animal feed or human consumption. To ensure thorough mixing, apply half the required amount of fungicide to the half-filled drill box, stir the grain well with a paddle, then add the remaining seed and fungicide and stir again.

Wettable powders are usually applied to seed in a commercial slurry machine. Liquids are commonly applied in various commercial, ready-mix, mist-type, or slurry-type treaters. Fungicides should be applied as close to the time of planting as possible.

The full benefits of seed treatment are not obtained unless combined with (1) planting disease-free seed, (2) rotation with nonrelated crops, (3) clean and deep plowdown of crop debris about every third year or when disease losses have been serious, if this is compatible with controlling soil erosion and (4) planting at the proper time, depth, and spacing.

RPD 1001

Before treating, read and follow all the manufacturer's directions on the container label. Do not use treated seed for food, feed, or oil purposes, even after it has been stored for months or years.

Fungicides registered by the federal EPA for seed treatment on field crops are listed in the table. All formulations of a fungicide are registered for the same crops.

Seed Treatment Chemicals

1. Captan (Captan, Orthocide) is registerd for use on essentially all field crops. Captan alone does not control smuts of small grains and grasses, but does give control of seed rots or decays and seedling blights (damping-off).

Captan seed protectant materials are sold as Stauffer Captan 25, 75, and 80 Seed Protectant, Captan 4 Flowable Seed Protectant, Captan 25 Planterbox Treater, Captan-Moly Planterbox Treater, and Captan-Moly Seed Protectant; Flow. Pro C Seed Protectant; Gallotox Captan FP-700R; Evershield Captan Seed Protectant; Orthocide 4 Flowable Seed Protectant; 80 Concentrate, 90 and 92 Seed Protectant Concentrate, 65 and 75 Seed Protectant; Ortho Soybean Seed Protectant and (MO); Chevron 90 Concentrate; Captan 80 and 95.

Agrosol-S, Granox, and Orthocide Maneb 30-30 Seed Protectant are 30:30 mixtures of captan and maneb. Granox P-F-M is a 30:30 combination of captan and maneb that also contains 1 percent molybdenum.

Stauffer Captan-Thiram 43-43 Seed Protectant contains 43 percent each of captan and thiram.

Orthocide-Vitavax 20-20 is a combination of captan and Vitavax (carboxin) for use as a planter box seed treatment. It contains 19 percent captan and 20 percent carboxin.

Vitavax-Captan HBM-25 is a combination of Vitavax 12.5% and captan 12.5% for use as a planter-box treatment.

Turner 4-Way Seed Protectant contains 18.75 percent captan, 18.75 percent maneb, 10 percent PCNB, and 2.5 percent etridiazol.

Other captan-HCB and captan-PCNB mixtures are mentioned below under hexachlorobenzene (HCB) and pentachloronitrobenzene (PCNB).

Captan is also sold in combination with various insecticides to control insects that feed on seed or seedlings. Combination products include:

a. Captan plus diazinon--Ortho Isotox Seed Treater (D), Hopkins Diazinon-Captan-Moly Seed Protectant and Diazinon Captan S.P., Agrox 2-Way, Two Way Seed Treater, Captan-Diazinon 37.5-25 Seed Protectant, Captan Diazinon 37.5-25 Planter Box Seed Protectant, and Agway Protector 2. Agrox Strep, a planter box seed treatment for corn, contains 20 percent captan, 2.5 percent diazinon, and 5 percent streptomycin.

b. Captan plus lindane--Ortho Isotox Seed Treater (F), Captan-Lindane 12.5-25 Planter Box Seed Protectant, and Orthocide Lindane 60-15 Seed Protectant.

c. Captan plus diazinon and lindane--3-Way Fungicide-Insecticide Seed Treatment, Captan-Diazinon-Lindane 33.5-11-16.6 Planter Box Seed Protectant, Agrox 3-Way, Agrox D-L Plus, and Three Way Seed Treatment.

d. Captan plus methoxychlor--Orthocide Methoxychlor 75-3 and 65-10 Seed Protectant, Gallotox Captan Methoxychlor 75-3, Stauffer Captan-Methoxychlor 75-2, 75-5, and 65-10 Seed Protectant.

e. Captan plus heptachlor--Captan Heptachlor 10-25 and Planter Box Seed Protectant.

f. Captan plus malathion--Evershield Seed Protectant With Captan and Malathion. Orthocide Malathion 75-1 Seed Protectant.

2. Carboxin (Vitavax Fungicide, Vitavax-25 DB Fungicide, Vitavax 200 Fungicide, Vitavax Flowable Fungicide, Vitavax-200 Flowable Fungicide, and Evershield V Seed Protectant) is registered for barley, corn, oats, and wheat. Vitavax is the only registered fungicide that systemically controls the loose smut fungi of wheat and barley. It also controls all other smuts of small grains including stinking smut or common bunt, covered and loose smuts of oats, and flag smut as well as certain seed-rotting and seedling blight fungi (such as *Rhizoctonia solani*) and barley stripe. Vitavax-25 DB, for use in the drillbox, controls smuts and other diseases of wheat and other small grains except rye. For wheat bunt control at least 1 ounce a.i. of carboxin per cwt. of seed must be used.

Vitavax 200 Flowable Fungicide contains 17 percent each of carboxin and thiram while Vitavax 200 Fungicide contains 37.5 percent carboxin and 37.5 percent thiram. These mixtures not only control all smuts of cereals but provide broad-spectrum control of seed rots and seedling blights (damping-off).

3. Fenaminosulf (Lesan 70% Wettable Powder Seed and Soil Fungicide and Lesan 70 Seed Protectant) is registered for use on corn and sorghums. It is available as a 70 percent wettable powder and is also sold in combination with PCNB (Terraclor). Lesan is specific for seed rot and damping-off fungi that are water molds (such as *Aphanomyces*, *Phytophthora*, *Pythium*). Lesan wets readily with water to form a slurry suitable for use in any commercial slurry treater or it can be applied as a dry mix.

4. Hexachlorobenzene (or HCB) is registered for use on barley, corn, oats, rye, soybeans, and wheat. It is available as wettable powders, dusts, and liquids for use in slurry, ready-mix, or mist-type treaters and as a dry mix for drill or planter box. HCB is sold as Anticarie and No Bunt 40 Seed Disinfectant. HCB is effective against seed- and soil-borne smuts (covered smuts of small grains and grasses, loose smut of oats, semiloose or nigra smut of barley), but has little or no activity against most seed decay and damping-off fungi. HCB is no longer manufactured in the United States. Therefore, some products such as Ortho HCB and Orthocide-HCB are no longer manufactured. Supplies of these materials may be used.

HCB is sold in combination with maneb or captan, chiefly for use on small grains, but anti-smut activity may be somewhat less than with pure HCB. The mixtures give good control of seed rots and damping-off.

HCB and captan is sold as Ortho Seed Treatment, HCB 4 Flowable Seed Protectant, Orthocide-HCB, Ortho Wheat Seed Protectant and Flowable, Ortho Drill Box Wheat Seed Protectant, Miller's HCB 4 Flowable, and Morgan HCB Flowable.

HCB and Maneb is sold as Granox N-M, Granox Flowable, Clean Crop M50-H10, and Maneb HCB 50-10 Planter Box Seed Protectant.

HCB and captan plus maneb is sold as Res-Q.

5. Mancozeb and Maneb are registered for use on barley, corn, oats, rye, sorghums, soybeans, and wheat. They are available as wettable powders, dusts, or flowables and sold as Manzate Maneb Fungicide and Manzate D Maneb Fungicide; Dithane M-22, M-22 Special, and M-45; Agsco DB Yellow and DB Green; and Agrox N-M Drill Box Non Mercurial. These products have fair activity against seed-borne smuts (covered smuts of small grains and forage grasses, loose smut of oats, semiloose or nigra smut of barley), and surface-borne Helminthosporium stripe of barley, with good activity against seed rots and seedling blights (damping-off).

Maneb is also sold in combination with lindane to control seed- and seedling-eating insects. Combination products include Agsco Be Green, Granol N-M, and Maneb Lindane 50-18.75 Planter Box Seed Protectant.

6. Pentachloronitrobenzene (or PCNB) is registered for use on barley, oats, and wheat. It is available as wettable powders, dusts, or emulsifiable concentrates (liquids) and sold primarily as Terra-Coat LT-2 and Terra-Coat 2-LF Seed Treatment Fungicides. It is effective against seed- and soil-borne smut fungi (covered smuts of small grains and forage grasses, loose smut of oats, semiloose or nigra smut of barley) and gives some protection against seed rots and seedling blights (damping-off).

7. Metalaxyl has an experimental use permit for Phytophthora and Pythium root rot control on soybeans. Full label is expected in early 1983. It is sold as Apron 2E.

PCNB and etridiazol (Terrazole) mixtures include Olin Terraclor Super-X and L-205, and SD-205 Seed Treatment Fungicides.

PCNB-captan mixtures are sold as Stauffer Captan-Terraclor 10-10 and 30-30 Seed Protectants; Orthocide PCNB 10-20 Dust; Ortho Soil Treater X and 3X; Terracap; PCNB-Captan 25-25 Wettable Powder; Terraclor 20-Captan 10 Dust, Terraclor 50-Captan 25 Wettable Powder, and PCNB-Captan 25-25 Wettable Powder.

A PCNB-Polyram mixture is sold as a 10:10 dust.

8. Polyram (or metiram) is registered for use on barley, oats, sorghums, and wheat. It is available as wettable powders and dusts. Polyram has good activity against most seed-borne smuts (covered smuts of small grains and forage grasses, loose smut of oats, semiloose or nigra smut of barley), seed rots, and seedling blights (damping-off) but may be somewhat erratic in action. Polyram is sold as Niagara Polyram 80WP, 7 Dust and Seed Treater; Polyram Wettable Powder; Agway Polyram 7D and Polyram 80W; Polyram Seed Treater; Naco Polyram Dusts; Polyram 80 Wettable Powder, and Polyram 7 Dust.

Seed Treatment Fungicides Registered for Use on Field Crops[a]

Fungicide	Alfalfa[b]	Barley	Broomcorn	Clovers[b]	Corn, field	Grasses, forage	Oats	Rye	Sorghums	Soybeans[b]	Wheat
Captan (Captan, Orthocide)[c]	X	X		X	X	X	X	X	X	X	X
Captan + Maneb (Agrosol-S, Granox, etc.)		X			X		X	X		X	X
Captan + Thiram		X			X				X	X	X
Captan + Zineb	X	X		X	X	X	X		X	X	X
Captan + HCB		X					X				X
Captan + HCB + Maneb (Res-Q)		X			X		X	X		X	X
Captan + PCNB (Captan-Terraclor, etc.) . .									X	X	X
Captan + Carboxin (Orthocide-Vitavax 20-20, Vitavax-Captan HBM-25)[d]		X					X			X	X
Carboxin (Vitavax)[d]		X			X		X				X
Carboxin + Thiram (Vitavax 200, Vitavax-T)[d]		X			X		X			X	X
Dichlone (Phygon)	X			X	X				X		
Fenaminosulf (Lesan)					X				X		
Hexachlorobenzene (HCB)		X			X		X	X		X	X
HCB + Maneb (Granox N-M, Granox-Liquid)		X			X		X	X		X	X
Mancozeb, Maneb		X			X		X	X	X	X	X
Metalaxyl (Apron 2E)										X	
PCNB (Terraclor, Terracoat LT-2, 2-LF) . .		X					X				X
PCNB + Etridiazol (Terraclor Super-X, Terra-Coat L-21, L-205, and SD-20) . .		X			X				X	X	X
Polyram, Metiram		X					X		X		X
Pyroxyfur (Grandstand)										X	
TCMTB (Busan, Cover-Up, Thiogem, etc.) . .		X			X		X			X	X
Thiram (Arasan, Panoram, Tinasad, etc.) . .	X	X		X	X	X		X	X	X	X
Thiram + Maneb					X						

[a]Use all seed treatment chemicals strictly according to label directions.
[b]Seed treatment is not normally suggested for alfalfa, clover, and soybean seed.
[c]For representative trade names of fungicides and combinations, see text.
[d]Controls loose smut of wheat and barley.

9. Pyroxyfur has an experimental use permit for Phytophthora and Pythium root rot control on soybeans. Full label is expected in early 1983. It is sold as Grandstand.

10. TCMTB is registered for use on barley, corn, oats, soybeans, and wheat. It is sold as Busan 30 and 72, Cover-Up L, Thiogem, and Protector-3L. TCMTB has activity against seed rots and seedling blights, all covered smuts, loose smut of oats, and semiloose or nigra smut of barley. It may be phytotoxic if improperly applied.

11. Thiram is registered for use on essentially all field crops except oats. It is available as wettable powders, dusts, and flowables. Thiram is sold primarily as Arasan 50-Red Thiram Seed Protectant, 50-Red ND Thiram Seed Protectant, 42-S Thiram Fungicide and Repellent, 70-S Seed Protectant, and 75 Thiram Seed Protectant; Evershield Seed Protectant; Chipco Thiram 75; Thiram 75; Tinasad; Rhodia Sup'r-Wet Thiram; Metasol Thiram 75%; Occidental Thiram; Fungisan, and Pearson's Moly-Stand Soybean Seed Protectant. Thiram has activity against most seed-borne smuts (all covered smuts, semiloose or nigra smut of barley), Helminthosporium stripe of barley, seed rots, and seedling blights (damping-off). Users should note that thiram alone or in combination may cause some user irritation.

12. Zineb is registered in combination with captan for use on alfalfa, barley, clovers, corn, forage grasses, oats, sorghums, soybeans, and wheat. It is available as wettable powders and dusts, and sold primarily as Zineb, Dithane Z-78, Black Leaf Sheen, Thiogreen Dust Fungicide, Naco Dithane 6 and 10 Dust, and Staples Dithane Seed Treating Dust. Zineb is formulated as a 21 percent WP in combination with 22 percent captan.

[*NOTES: (1) Seed treatment is not normally suggested for alfalfa and clovers. (2) See Report on Plant Diseases (RPD) #506 "Soybean Seed Quality and Fungicide Seed Treatment" for more information on soybean seed treatment. (3) RPDs are available from the Department of Plant Pathology, N533 Turner Hall, 1102 S. Goodwin, Urbana, IL 61801 at a cost of fifteen cents each. (4) Mention of a trade name or proprietary product does not constitute warranty of the product and does not imply approval of this material to the exclusion of comparable products.*]

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Northern Corn Leaf Blight

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Northern corn leaf blight, caused by the fungus *Helminthosporium turcicum* (sexual stage *Trichometasphaeria turcica*), is common in most humid areas of the world where corn is grown. In the Corn Belt, northern corn leaf blight usually does not appear in fields before silking. It may occur throughout Illinois but is found mainly in the northern third of the state.

When the disease becomes well established on the lower third of the plants before tasseling, reduction in grain yield may reach 30 to 50 percent. If the infection is moderate or is delayed until six weeks after silking, yield losses are minimal. In addition to reduced yield, the feed value of fodder is lowered and leaf-blighted plants are predisposed to stalk rots. Lodging may also be severe where leaf blight is present.

Races of *H. turcicum* from corn can infect Sudangrass, Johnsongrass, and sorghum, but the reverse has not been reported.

Infection by *H. turcicum* is favored by moderate temperatures of 65° to 85° F. (18° to 29° C.), frequent light showers, and heavy dews. Northern corn leaf blight thrives at somewhat lower temperatures than southern corn leaf blight (see *Report on Plant Diseases* No. 209). Dry years check the incidence of the disease.

Symptoms

This disease is characterized by long, elliptical, grayish green or tan lesions on the leaves that usually develop first on the lower leaves. Typical lesions are two to four inches (5 to 10 cm.) long by half an inch (1.25 cm.) wide. Occasionally, the lesions may attain a length of six inches (15 cm.) and a width of one and a half inches (3.75 cm.). The lesions on resistant hybrids possessing the resistance genes Ht_1, Ht_2, and Ht_3 vary in their shape and size, but all are characterized by a chlorotic (yellowish) border. The lesions may be easily mistaken for those caused by *Erwinia stewartii* (see *Report on Plant Diseases* No. 201, "Stewart's Leaf Blight of Corn"). During damp weather, masses of dark, grayish black spores (conidia) of the fungus are produced on the surfaces of infected leaves. These conidia often form in concentric zones, giving a targetlike appearance to the lesion. Ears and kernels are *not* infected, although grayish green to tan lesions may form on the outer husks.

The lesions may become so numerous that nearly all the leaf blade is killed. The leaves then become grayish green and brittle and resemble leaves killed by frost or drought injury.

Disease Cycle

The northern corn leaf blight fungus overwinters locally in Illinois as mycelia and conidia on the surface or in infected leaves (primarily midrib and leaf sheath), husks, and other plant parts. Conidia can be transformed into thick-walled chlamydospores. Overwintering depends upon the strain of the fungus and the specific inbred or hybrid infected. During warm, moist weather in the spring, conidia are formed from the mycelium in the corn debris. These conidia may be carried long distances by wind or locally by rain to the lower leaves of growing corn plants, where the spores germinate and the resulting germ tubes penetrate the leaf tissue. Secondary spread within and between fields occurs by conidia produced abundantly on leaf and husk lesions.

Widespread infections result when the spores are abundant and conditions are favorable for early and continuous development.

Infection by conidia is initiated when free water is present on the leaf surfaces for 6 to 18 hours and the temperature is between 65° and 80° F. (18° to 27° C.). Lesions are evident 7 to 12 days after infection. Successive crops of spores are produced on the leaf lesions and spread to higher leaves. Under ideal conditions for the disease, the entire plant may turn grayish green and die prematurely by late August.

Three biotypes of *H. turcicum* have been described. One biotype (race 1) is avirulent on all Ht sources of resistance. The second biotype (race 2) is virulent on Ht_1 but not on Ht_2, Ht_3, or HtN. The third biotype (race 3) is virulent on Ht_2 and Ht_3 but not on Ht_1 or HtN. All three biotypes have been reported in Illinois, but the first two are the most prevalent.

The sexual stage of the northern corn leaf blight fungus is not known to occur in nature. It has been obtained in pure culture in the laboratory by mating compatible isolates of the fungus.

Control

1. Northern corn leaf blight is most effectively controlled by planting resistant hybrids and varieties. Hundreds of highly resistant dent corn hybrids, adapted to different growing areas of the Corn Belt and elsewhere, are available. Resistance is usually directly proportional to the number of resistant inbreds used in making up the hybrid.

   There are two types of lesions: (1) fewer and smaller lesions (multigenic resistance); and (2) chlorotic (yellowish) lesions. Few or no spores are produced on the chlorotic lesions (monogenic resistance or Ht genes).

   There is good evidence of phytoalexin production associated with monogenic resistance. The phytoalexin, released by the plant in response to the presence of the fungus, inhibits the growth and sporulation of *H. turcicum*.

2. When feasible, cleanly plow down corn debris before planting. In fields where minimum or conservation tillage is practiced, the disease is sometimes more severe than in fields where corn debris is plowed under prior to planting. However, clean plowing should be practiced only where soil erosion is not a hazard.

3. Maintain high balanced fertility based on a soil test.

4. Control weeds and insects by following suggestions of University of Illinois Extension specialists.

5. Northern corn leaf blight has been successfully controlled on sweet corn and seed-production fields of dent corn with fungicide sprays containing chlorothalonil,[1] maneb,[2] zineb,[3] and mancozeb or maneb plus zinc-ion.[4,5] These fungicides are *protectants only*. Two to four applications are needed at 7- to 10-day intervals, starting when the first lesions appear (one to five lesions per plant). This treatment is not usually economical in Illinois, except in hybrid-corn seed fields and late-maturing sweet corn raised for the fresh market.

   The following fungicides, with the restrictions noted, may be applied:

   Chlorothalonil. Cleared for use only on fresh market sweet corn up to 14 days before harvest. Do *not* feed treated forage to livestock.

   Maneb. Cleared for use on sweet corn only. Do *not* feed treated forage or seed to livestock. Grain from treated plants may be used for livestock feed.

   Mancozeb (maneb and zinc-ion). Cleared for use on field corn and hybrid seed corn. Treated plants can be fed--as silage (fodder) or grain--with a 7-day limit after the last application.

   Zineb. Cleared for use on field and sweet corn. Do *not* feed treated forage or seed to dairy animals or animals being finished for slaughter. Grain from treated plants may be used for livestock feed.

   All treatments should be *thoroughly* applied at the suggested label rate, with a minimum of 20 to 30 gallons of water per acre for ground application, and at least five gallons of water for application by aircraft (fixed wing or helicopter). Add one pint of commercial surfactant per 100 gallons of water as a sticking-spreading agent. It is essential that both the upper and lower surfaces of all leaves be covered with each spray. Use the smallest nozzles possible, and take all precautions to avoid drift.

6. Seed treatment and crop rotation are not effective controls for this disease.

(Note: RPDs are available from the Department of Plant Pathology, N533 Turner Hall, 1102 S. Goodwin, Urbana, IL 61801 at a cost of fifteen cents each.)

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[1]Chlorothalonil is sold as Bravo W-75, Bravo 500, Daconil 2787, Daconil 2787 Flowable Fungicide, and Diamond 75% Chlorothalonil.

[2]Maneb is sold as Manzate Maneb Fungicide, Dithane M-22 and M-22 Special with Zinc, Pennwalt Maneb 80, Chevron Maneb, Black Leaf Maneb Fungicide, Patterson's Maneb Fungicide, Aceto Amazin Maneb 80 and Maneb Flowable, Manzate D Maneb Fungicide, Ortho Maneb 80 Fungicide, and BASF Maneb 80 WP.

[3]Zineb is sold as Dithane Z-78, Science Zineb Fungicide, Ortho Zineb Wettable, Niagara Zineb 75 Wettable, Pennwalt Zineb W-75, Chipman Zineb, Stauffer Zineb 75-W, Aceto Zineb-75, Black Leaf Sheen, Acme Zineb 75W Fungicide, Sherwin-Williams Zineb, E-Z-Flo Zineb 75, Miller Zineb 75%, Chempar Zineb 75 WP, Shepard Chemical Zineb, BASF Zineb 80 WP, and Superior's Zineb 75% Wettable.

[4]Mancozeb or maneb and zinc-ion is sold as Dithane M-45, Manzate 200 Fungicide, Amazin Zinc Enriched Maneb 80 Fungicide, and Sup'-r-Flo Maneb Flowable.

[5]Mention of a trade name or proprietary product does not constitute warranty of the product and does not imply approval of this material to the exclusion of comparable products.

Corn Stalk Rots

B.J. Jacobsen, D.G. White, and M.C. Shurtleff

Stalk rots are the most common diseases of dent corn in Illinois. These diseases reduce annual yields by a minimum of five percent. Losses in certain years reach 10 to 20 percent of the expected yield. Losses are due to (1) premature plant death, which results in poor filling of ears or light test weights for the grain and (2) harvest losses associated with stalk breakage or lodging. Problems with ear rot are usually greater where lodging occurs, particularly when the harvest season is wet.

Several fungi and bacteria can cause stalk rots. Stalk rot is usually due to the combined effects of more than one organism. The common stalk rot diseases caused by fungi in Illinois include: Gibberella stalk rot *(Gibberella zeae or Fusarium graminearium)*, anthracnose *(Colletotrichum graminicola)*, Fusarium stalk rot *(chiefly Fusarium moniliforme)*, and Diplodia stalk rot *(chiefly Diplodia maydis)*. In hot dry seasons, charcoal stalk rot caused by *Macrophomina phaseolina* may be prevalent. Pythium stalk rot is usually rare but may occur if the weather is excessively wet during the summer months.

Bacterial stalk rot *(Erwinia chrysanthemi* pathovar *zeae)* is not common in Illinois and rarely causes significant damage. Occasionally, bacterial stalk rot appears before tassel emergence on random corn plants following heavy rains.

Symptoms

Stalk rots caused by *Gibberella*, *Fusarium*, and *Diplodia* fungi are not usually apparent until several weeks after pollination. Diseased plants die suddenly in various areas within the field. The leaves die first and turn a dull grayish green, similar to the color caused by frost or drought damage. Death of the entire plant follows within 7 to 10 days in susceptible hybrids. The lower internodes turn from green to tan, straw-colored, or dark brown and are spongy and easily crushed. When the stalks are split lengthwise, only the vascular strands are intact and the pith tissue is decayed.

Stalks infected with the *Gibberella* fungus have a characteristic pink to reddish discoloration of the pith and vascular strands. Fusarium stalk rot appears similar to *Gibberella*, except that the discoloration of infected tissues commonly varies from whitish pink to salmon. Rotting commonly affects the roots, crown, and lower internodes. The breakdown of pith tissues starts at the nodes soon after pollination and becomes more severe as the plant matures. In addition, small, round, bluish black perithecia (fungal fruiting bodies) are formed on the surface of Gibberella-infected stalks in the fall or during the following spring. These fruiting bodies are easily scraped off with a thumbnail.

Anthracnose stalk rot *(Colletotrichum graminicola)* or top-dieback has become much more prevalent in Illinois since the early 1970s. Unlike most other stalk rot diseases, the *Colletotrichum* fungus can destroy several internodes of the stalk and may cause top-kill and lodging as well as the death and lodging of the entire plant.

The fungus may also cause a leaf blight. Very susceptible hybrids may be killed before pollination. Most hybrids, however, are killed only a week or two before normal maturity. A shiny black or dark brown discoloration of the rind late in the season is typical of anthracnose. This black discoloration usually extends up the stalk for several internodes and may uniformly discolor the rind or give it a blotchy or speckled appearance.

Diplodia stalk rot can be distinguished from other stalk rot diseases by the numerous, small, raised, black dots (pycnidia) produced by the fungus clustered on or near the lower nodes of infected stalks. White mycelial growth may also be present on the surface. Unlike the perithecia formed by the *Gibberella* fungus, the pycnidia of *Diplodia* are embedded in the rind and cannot be scraped off with a fingernail. Occasionally, individual stalks will have fruiting bodies of both fungi.

Charcoal rot is most abundant in hot dry seasons. Soil temperatures near 99° F. (37° C.) are favorable for disease development. The symptoms appear as plants approach maturity. Stalks are killed and the interior of the lower internodes disintegrates. The disease is distinguished by the presence of numerous, small, round to irregular, black fungal bodies (sclerotia), which are present in large numbers along the vascular strands in the interior of rotted stalks and give them a charred appearance. Sclerotia may also be found just beneath the stalk surface and on the roots.

Pythium stalk rot usually occurs during extended hot (optimum 90° F. or 32° C.), wet weather from late June to September. The disease is most common in river-bottom fields where the air and soil drainage is poor and the humidity is high. The interior of the stalk looks water soaked. Usually, only a single internode just above the soil line is soft and brown. Plants often collapse, remaining green and turgid for several weeks because the vascular bundles remain intact. Postive diagnosis can be made by microscopic examination for the round thick-walled oospores of the *Pythium* fungus in diseased tissue.

Bacterial stalk rot usually appears as a tan to dark brown, water-soaked, soft or slimy disintegration of pith tissues at a single internode. Affected stalks suddenly collapse and are usually twisted. The tips of the uppermost leaves often wilt, followed by a slimy soft rot at the base of the whorl. The decay spreads rapidly downward until the affected plants collapse. Affected plants often have a disagreeable odor. The development of bacterial soft rot, like Pythium stalk rot, is favored by high temperatures (85° to 95° F., 29° to 35° C.) and poor air circulation. General infection may occur following flooding and where corn is sprinkler-irrigated from a surface source of water, such as a river, farm pond, or lake.

Disease Development

Development of stalk rots is generally favored by an early environment that encourages kernel set and by a late environment that is stressful. Post-flowering stresses may include an excess or lack of moisture; nutrient deficiency or imbalance; excessive cloudiness; insect, nematode, hail, or other mechanical injury to the stalks or roots; loss of effective leaf area due to a foliar disease; and an excessive plant population. Extended periods of very dry or wet weather prior to pollination, followed by an abrupt change for several weeks after silking, favor the development of stalk rot.

High yields are often associated with stalk rot problems. Plants can overcommit to yield when environments are ideal through the pollination period and stress occurs afterwards. When stress occurs, the large number of kernels places a high demand on the plant for sugars. If photosynthesis, which produces sugars, is reduced because of stress, the kernels will draw sugars from stalk tissue and deprive the roots of adequate nutrients. Cloudy weather following pollination is the most common stress factor because photosynthesis is reduced by 40 to 50 percent as compared with levels that occur on bright cloudless days.

High nitrogen (N) levels combined with a low level of potassium (K) may increase stalk rot. However, high rates of nitrogen balanced with adequate to high levels of potash (K_2O) do not increase the potential for stalk rot. Adequate to high levels of nitrogen followed by a loss of available nitrogen due to denitrification or leaching may dramatically increase the incidence of stalk rot.

Injury to roots, stalks, or leaves by nematodes, diseases, insects, hail, or equipment can also increase the incidence of stalk rot. Injuries created by European corn borers, northern and western corn rootworms, and other insects often provide avenues of entry for stalk rot fungi. Although not clearly established experimentally, observations indicate that the incidence of stalk rot is increased by nematode damage. High populations of root-lesion *(Pratylenchus* spp.) and spiral *(Helicotylenchus* spp.) nematodes have been associated with increased stalk rot. Hail injury may predispose plants to stalk rot primarily because the effective leaf area is reduced. The loss of photosynthetic leaf tissue because of diseases such as northern corn leaf blight, southern corn leaf blight, Stewart's leaf blight, yellow leaf blight, and anthracnose also increases the incidence and severity of stalk rot.

Control

Stalk rots cannot be entirely controlled. However, the damage can be reduced through the conscientious use of an integrated control program. Use the following practices to reduce harvest losses: (1) plant well-adapted disease-resistant hybrids; (2) practice balanced soil fertility; (3) control insects; (4) plant at the proper rate; (5) avoid stress through proper irrigation, soil management, and foliar disease and weed control; and (6) practice regular field scouting.

1. Corn growers should select hybrids that have stalk rot and leaf disease resistance, good standability, and high yield potential. Full-season hybrids are generally more resistant than those that mature early in a given area. Resistance to the fungi that cause stalk rots helps prevent losses from premature plant death and lodging. Many resistant hybrids are available. Most hybrids, however, are only resistant to the organisms causing Diplodia, Gibberella, and Fusarium stalk rots. Hybrids that are resistant to these fungi may be highly susceptible to anthracnose stalk rot. Hybrids resistant to anthracnose may be somewhat susceptible to other stalk rot fungi. Thus, it is important to know which organisms are causing major stalk rot damage in an area and to what stalk rot fungi a hybrid is resistant.

   In addition to stalk rot resistance, growers should select hybrids resistant to foliar diseases important in their area. Resistance to leaf diseases is important since loss of leaf area can predispose the corn to stalk rot problems. Disease-risk maps for foliar and other diseases of corn can be found in *Report on Plant Diseases* No. 212, "Illinois Corn Disease Management Program."

Hybrid standability is another factor that should be considered. Hybrids with a thick rind or other characteristics that increase standability often remain standing even though the interior of the stalk is thoroughly decayed. Corn producers should check out such characteristics before selecting a particular hybrid. It is often worthwhile to tour local hybrid strip plots to check on the susceptibility of various hybrids to stalk rot. Up-to-date information on the yield performance and lodging of many hybrids is also available in the latest issue of the circular *Performance of Commercial Corn Hybrids in Illinois*.

2. Balanced soil fertility, particularly with respect to potassium, is important. A high level of nitrogen along with a low level of potassium can increase the losses from stalk rot. However, a high rate of nitrogen with adequate-to-high potassium availability does NOT necessarily increase the potential for stalk rot. Information on suggested nitrogen and potassium rates can be found in the latest issue of the Extension Circular *Illinois Agronomy Handbook*, available at all county Extension offices. Fertilizer should be applied based on the results of soil tests.

   Recent research has shown the importance of an adequate supply of nitrogen throughout the season in reducing the severity of stalk rot. High levels of nitrogen followed by a loss of nitrogen due to denitrification or leaching may increase the severity of stalk rot dramatically. In areas where leaching or denitrification is expected, the use of a nitrification inhibitor, such as N-Serve (Dow Chemical Co.), may help reduce stalk rot.

3. Control of insects such as the European corn borer and the northern and western corn rootworms is important in reducing stalk rot losses. Corn growers should follow the cultural and chemical recommendations of University of Illinois Extension entomologists as given in Extension Circular 899, *Insect Pest Management Guide, Field and Forage Crops*. The use of scouting procedures will reduce unnecessary application of pesticides and increase yields because applications will then be made at the precise time for optimum results.

4. Corn growers should plant at populations suggested for the particular hybrid, soil type, fertility level, available soil moisture, and productivity potential in a given field. Planting at "excessive" rates can result in spindly stalks with a reduced standability. Growers should consult seed-corn handbooks for suggestions on planting rates for hybrids.

5. Timely irrigation (where possible), weed and nematode control, and other stress-reducing practices are important in reducing stalk rot losses.

6. Monitoring (or scouting) fields on a weekly basis is the best way to determine pest levels in a field. Corn producers should begin to scout fields for stalk rots (lodging potential) when the corn contains 30 to 40 percent moisture. An effective scouting procedure is to walk a zig-zag pattern through the field while pinching the stalks below the lowest node to check for firmness or pushing random plants (a minimum of 100) five inches from the vertical. If more than 10 to 15 percent of the plants lodge using this procedure, it would be beneficial to harvest the field early to prevent potential harvest losses. The same procedure can also be used to assess hybrids in strip plots. Growers should also check the extent of premature plant kill when inspecting strip plots.

By regularly scouting and rating fields for disease, insect, and weed infestation during the season, growers can carry out timely and effective measures WHEN they are needed. Knowing which fields have the greatest potential for stalk and ear rots will help reduce losses by enabling the grower to schedule those fields for early harvest.

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The Soybean Cyst Nematode Problem

B.J. Jacobsen, D.I. Edwards, G.K. Noel, and M.C. Shurtleff

Soybeans severely infected with the soybean cyst nematode (*Heterodera glycines* Ichinohe, 1952) become stunted and yellow or chlorotic and may even be killed. The damage is usually worst on the lighter, sandy soils, but drastic losses have been observed on the heavy soils typical of much of the soybean acreage in Illinois. Yield losses can range from 10 to 80 percent depending on rainfall, soil fertility, presence of other diseases, and population of the nematode.

The damage caused by soybean cyst nematodes can be greatly accentuated if the infected soybean plants are exposed to drouthy periods and root-rotting fungi. Rotating to nonhost plants such as corn or sorghum, eliminating weed hosts, and using a nematicide will tend to delay or perhaps prevent soybean cyst nematode populations from increasing to damaging levels.

The soybean cyst nematode has been identified in most counties in the southern half of Illinois as well as in several counties in the northern half of the state (Figure 1). Undetected infestations are probably present in most other counties. An awareness of the problem will help in efforts to spot new and potentially devastating infestations.

Symptoms and Identification

Unfortunately, the aboveground symptoms of damage on individual plants and the appearance of infested fields are usually not specific enough to allow positive identification. However, some symptoms are quite suggestive of infection by this nematode. Heavily infected plants are stunted and may be yellow or chlorotic, particularly in soils of low fertility or during drouth conditions. Badly infested portions of a field may be oval to somewhat rectangular in outline. Such portions have a general yellowish cast and show the most severe damage in the center, with less damage toward the margin.

Many other conditions may cause the same or similar symptoms. Therefore, identification cannot be made on the basis of aboveground symptoms alone. Growers should notify their county Extension adviser at once if they see the conditions described above in their soybean fields, or they should contact an Extension plant pathologist at the University of Illinois, Urbana, IL 61801 (Telephones: (217)333-8414 and 333-1845). Special arrangements must be made for collecting and shipping samples (see *Report on Plant Diseases* No. 1100, "Collecting and Shipping of Soil Samples for Nematode Analysis"). Final identification cannot always be made with the unaided eye. The nematodes must be recovered from infested soil or plant roots and identified under a microscope or with a hand lens.

Field diagnosis can be done by digging up plants on the margins of suspected damaged areas and gently washing the soil from the roots. The presence of white to brown, lemon-shaped cysts on the soybean roots provides positive diagnosis. The absence of cysts, however, does not mean that the soybean cyst nematode is not involved. Soil samples should be submitted in such cases.

RPD 501

The Nematode and Its Life History

Soybeans are infested by the second-stage larva--a microscopic (1/60 inch long), colorless worm (Figure 2). Larvae penetrate the soybean by puncturing the roots with a spear-like feeding structure, the stylet. Once inside the root, they migrate toward food-conducting tissues where they feed and mature. Feeding alters the internal root structure, thereby interfering with normal root functions and ultimately causing plant damage. In approximately three weeks under optimum conditions, mature males and females develop from the larvae.

The females enlarge greatly as they develop, becoming lemon-shaped. They break through the root surface while remaining attached to the root by the head. The females lay some eggs in a jellylike mass in the soil but retain most of the eggs within their swollen bodies. If an infected plant is dug at this stage, the attached females can be seen with the unaided eye as shiny, white, spherical bodies somewhat smaller than a pinhead. This is the so-called white female stage.

After death, the white female stage changes from yellow to brown--the brown cyst stage. By the time brown cysts are formed, the cyst (the altered female body wall) has become a protective structure containing many viable eggs. The cyst wall protects the eggs from drying, chemical action, predators, and parasites. For these reasons, the brown cyst stage is best suited for the spread of the nematode to new areas. One female can produce up to 600 eggs, and as many as five generations can be completed in a single growing season. Thus, if one cyst containing 400 eggs is introduced into a soybean field in the spring, over 10 trillion cysts could be produced in one growing season. Thus, the introduction of even a single cyst into a field represents a potentially high nematode population that could cause noticeable damage within a short time.

The five described races of the soybean cyst nematode are designated 1, 2, 3, 4, and 5. These races are characterized by their ability to reproduce on certain soybean varieties (Table 1). Race 3 is the common one found in Illinois.

Resistant soybean varieties, such as Forrest, Custer, and Franklin, can be grown without losses in the presence of Race 3 (see the section on resistant varieties). Race 4, found first in Arkansas and later in Missouri and Tennessee, causes severe damage on varieties resistant to Race 3. Damaging levels of Race 4 have occurred in a number of central and southern Illinois counties and may be present in other areas of the state. In a few southern Illinois counties, populations have caused severe damage on varieties resistant to Races 3 and 4. Some of these populations have been identified as Race 5, which has also been identified in Minnesota. Procedures have been developed for determining the races of the soybean cyst nematode. Race determinations are made available as a grower service by the University of Illinois at Urbana-Champaign. For information, contact your county Extension adviser in agriculture.

Experienced personnel can determine the most prevalent race present in a field by planting one or several small areas (two to three rows, 5 to 10 feet long in areas of the field showing damage) to a Race 3-resistant variety (such as Franklin, Custer, or Forrest), to a Race 3- and 4-resistant variety (such as Bedford, Fayette, or Nathan) and to a susceptible variety normally used by the grower. If no cysts appear on the roots of the Race 3- and Race 4-resistant varieties after six to eight weeks, but cysts can be seen on the roots of the susceptible variety, the predominant race is 3. If cysts are obvious on the roots of the susceptible and the Race-3-resistant variety, but not on those of the Race 3- and 4-resistant variety, Race 4 is the predominant race. If cysts are obvious on all varieties, a race other than Race 3 or 4 is present.

Race 3-resistant varieties can be grown and combined with crop rotation for control if only Race 3 is detected. If Race 4 is detected by growers in the southern tip of the state, they should consider growing varieties such as Nathan, Bedford, or Fayette, which are resistant to Races 3 and 4. Bedford and Nathan are late-maturing varieties (Maturity Group V) and are only adaptable to far southern Illinois. If Race 4 is detected in the central portion of the state, growers should plant the Fayette variety, which is resistant to Races 3 and 4. In all situations, growers should use rotation with nonhost crops since continuous planting to a resistant variety is likely to lead to the selection of a soybean cyst nematode race that can attack the resistant variety used. In one research plot where the variety Franklin was planted for three years, a new race was detected by the end of the third year.

Host Plants

The host range of the soybean cyst nematode includes leguminous field crops plus some ornamental plants and certain weed species that are susceptible and will increase nematode populations. These hosts are shown in capital letters in Table 2. Other plants listed allow cyst production but are not often associated with soybean production in Illinois.

How Nematodes Spread

Cysts occur throughout the root zone in the soil. Some accumulate on the soil surface. From there, they can easily be transported alone or with soil by man and by natural agents. Cysts may be found in the mud adhering to farm implements, machines, vehicles, tools, shoes, or other mud-carrying items. The cysts also can adhere to boxes, crates, cartons, and bags and can be moved in this way whether or not mud is present. Nursery stock, transplants, bulbs, corms, and root crops may carry cysts in adhering soil, even though the plants themselves are not being attacked by the nematodes. Hay, straw, grain, or seed crops that carry dust or soil peds may also serve as carriers. Basically, anything that moves through an infested field in contact with the soil is capable of picking up and transporting cysts, although equipment and contaminated soybean seed that has not been thoroughly cleaned appear to be the most important means of spreading soybean cyst nematodes in Illinois.

Natural agents may also be important in the spread of the soybean cyst nematode. Wind, runoff water, livestock, and wildlife can carry cysts into clean areas. Even waterfowl and other birds feeding in infested fields may pick them up and carry them considerable distances.

Control: An Integrated Approach

An ideal program to control soybean cyst nematodes (SCN) should integrate the following: detection, crop rotation, resistant varieties, nematicides, soil fertility, sanitation, and soil analysis.

Detection

Identifying the problem is the first step in control. Soybean producers should be familiar with SCN symptoms and should suspect SCN where yields are reduced without explanation.

After an SCN infestation is identified, the predominant race present should be determined using the procedure described earlier. After the race has been determined, an economic analysis of control alternatives should be made to determine the best control strategies for a particular farm.

Crop Rotation

Crop rotation is a powerful tool for controlling SCN and other diseases. The effect of crop rotation is shown in Table 3. The data show that after three years in a nonhost crop, SCN populations were low enough at the Fayette County research location to safely plant a susceptible variety. SCN populations were reduced between 50 to 90% each year a nonhost crop was planted.

Rotations with nonhost crops such as corn, sorghum, red clover, alfalfa, and sunflower and with SCN-resistant soybeans are effective because SCN larvae hatch from eggs as long as soils are between 60-90° F. Optimum hatch occurs at 72° F. The second stage larvae have food reserves to last seven to fourteen days, depending on soil temperature, after which time they must establish a feeding site in a host plant. Thus, if no host plant is available, data indicate that between 50 to 90% of the SCN population is eliminated by starvation each year. Even greater reductions may occur where eggs or larvae are attacked by parasites and predators such as fungi and mites.

Four crop rotations are suggested below that should minimize and may eliminate yield losses to SCN. Note that resistant varieties should not be used alone since experience has shown that this practice will lead to the development of high populations of an SCN race that can attack the resistant variety.

1. Crop Rotation #1
   Year 0—identification of a problem with Race 3
   Year 1—nonhost crop (e.g., corn, sorghum, sunflower, alfalfa, and red clover)
   Year 2—adapted Race 3-resistant soybean variety
   Year 3—nonhost crop
   Year 4—susceptible soybean variety if soil analysis shows SCN populations are below threshold level; otherwise, plant a nonhost crop and repeat soil sampling
   Year 5—repeat rotation

2. Crop Rotation #2
   Year 0—identification of a problem with Race 3 or 4
   Year 1—nonhost crop (e.g., corn, sorghum, sunflower, alfalfa, and red clover)
   Year 2—adapted Race 3- and 4-resistant soybean variety
   Year 3—nonhost crop
   Year 4—susceptible soybean variety if soil analysis shows SCN populations are below threshold level; otherwise, plant a nonhost crop and repeat soil sampling

3. Crop Rotation #3, for use where resistant varieties are not adapted or available.
   Year 0—identification of SCN problem
   Year 1—nonhost crops (e.g., corn, sorghum, sunflower, alfalfa, and red clover)
   Year 2—nonhost crop (e.g., corn, sorghum, sunflower, alfalfa, and red clover)
   Year 3—nonhost crop (e.g., corn, sorghum, sunflower, alfalfa, and red clover)
   Year 4—susceptible soybean variety if soil analysis shows SCN populations are below threshold level; otherwise, plant a nonhost crop and repeat soil sampling

4. Crop Rotation #4, for use where continuous soybeans are planted. This is the least desirable rotation plan because of the potential buildup of new races of SCN and other diseases under continuous soybean culture.
   Year 0—identification of a problem with Race 3
   Year 1—Race 3-resistant variety
   Year 2—Race 3- and 4-resistant variety
   Year 3—Race 3- and 4-resistant variety
   Year 4—susceptible soybean variety if soil analysis shows SCN populations are below threshold level; otherwise, plant a nonhost crop and repeat soil sampling

Ideally, a nonhost crop should be planted after an SCN problem is identified because SCN exist naturally as a mixture of races and a nonhost crop will reduce the population of all races. If a resistant variety is planted immediately, that part of the native population able to attack the resistant variety will increase.

The value of crop rotation should not be underestimated. A grower will achieve higher yields on all crops involved in the rotation than on any one crop that is planted continuously. This result is well illustrated by a long-term study on several Agronomy research fields located throughout Illinois. In this study, yields were compared in fields where soybeans and corn were planted continuously and where corn and soybeans were planted in rotation. Soybeans planted in rotation yielded, on the average, approximately 5 bu/A more than continuous soybeans, and corn planted in rotation yielded approximately 12.5 bu/A more than continuous corn. These studies, conducted in the absence of SCN, show the positive economic impact of rotation. Therefore, growers should compare the yields and the economic return of rotated crops versus the yields and returns of continuous soybeans. An example of such a comparison is given below based on the following assumptions:

Average corn yields	125 bu/A	@ $2.70	$134.00/A direct costs
Average soybean yields	40 bu/A	@ $6.40	$ 72.00/A direct costs

	Corn-Soybean Rotation		Continuous Soybeans	
	Yield (bu/A)	Net return/A	Yield (bu/A)	Net return/A
Year 1	125 bu corn	$ 203.50	40 bu	$ 184.00
2	40 bu soybean	184.00	35 bu	142.00
3	125 bu corn	203.50	35 bu	142.00
4	40 bu corn	184.00	35 bu	142.00
5	125 bu corn	203.50	35 bu	142.00
		$ 978.50		$ 752.00

In this example, the grower made $226 more per acre over 5 years with rotation. Added benefits of rotation are the better weed control achieved by rotating herbicides and corn rootworm control. Growers should do this comparison with their average yields and expected crop prices. With rotation a SCN problem is less likely to develop and is easier to manage if it does develop.

Resistant Varieties

SCN-resistant varieties are an excellent control tool for use in a SCN management program. However, this tool can be eliminated by the development of new races of SCN. Also, high-yielding resistant varieties are not available for all areas.

The data given in Table 4 reflect the yields of high-yielding susceptible varieties and SCN-resistant varieties in the presence and absence of SCN. At the present time, no SCN-resistant variety will yield as much as high-yielding susceptible varieties although the variety Fayette is within 5 percent of commonly susceptible varieties. Therefore, growers should plant resistant varieties only where an SCN problem exists. Also, planting an SCN-resistant variety unnecessarily could lead to the selection of a race of SCN that could attack that variety. Table 5 lists the public soybean varieties resistant to SCN, the type and source or resistance, and the maturity group. There are several private varieties available with resistance to one or more races of SCN.

Nematicides

The nematicides Mocap 10G, Nemacur 15G, Nemacur 3E, Furadan 10G, and Temik 15G are labeled for SCN control. These granular insecticides are applied in bands over the row at planting. Furadan 10G and Temik 15G are also labeled for in-furrow application. The data in Table 6 are the average yields of SCN-susceptible soybean varieties treated and untreated with nematicides and the average yields of SCN-resistant soybean varieties. Over the years, Temik 15G has given the most consistent increase in yield, but resistant varieties have produced higher yields than the best nematicide treatment at the Franklin County research site. However, the best nematicide treatment produced higher yields than the best resistant variety at the Vermilion County research site. In general, nematicide use should be considered only where adapted resistant varieties are unavailable or where susceptible varieties are planted when SCN populations are above the threshold level.

Soil Fertility

The data in Table 7 show that high fertility is required to achieve optimal yields of the SCN-resistant variety Franklin. It also should be noted that the susceptible variety Union did not have yields as high as the SCN-resistant variety Franklin. Therefore, fertility alone will not eliminate yield losses from SCN.

The data given in Table 8 show that high fertility is required to realize the full potential of Temik® nematicide treatment.

Therefore, soybean growers should make sure adequate levels of phosphorus and potash are present before initiating an SCN control program.

Sanitation

Since SCN moves with infested soil, soybean producers with SCN-infested fields can reduce the likelihood of spread to other fields by washing soil from equipment used in infested fields before moving the equipment to noninfested fields.

Since SCN is often carried in soil peds, seed produced on infested ground should be thoroughly cleaned to remove soil peds before planting. Seed purchased from infested areas should have been cleaned by a spiral cleaner before planting.

Another common source of SCN contamination is second-hand farm equipment. Such equipment should be washed free of all adhering soil prior to use.

Soil Analysis

Soil analysis for SCN should always be done before a susceptible variety is planted without nematicide protection. At the present time, a soil population below 20 viable eggs and larvae per 100 cc. of soil is considered to be the population at which a susceptible variety can be planted without significant damage. Growers who want to plant a susceptible variety as soon as possible in the rotation should sample each nonhost crop in the fall to determine the remaining population. If populations increase after cropping to a resistant variety, the buildup of a new race should be suspected.

Soil samples should be collected to a depth of 6 inches. Approximately 10 or more subsamples per 5 acres should be taken. Subsamples should be mixed and a composite sample should be sent to the University of Illinois Plant Clinic, St. Mary's Rd., Urbana, IL 61801, for analysis. A nominal charge will be made for processing samples.

Controlling Soybean Cyst Nematode in Snapbeans, Kidney Beans, Lima Beans, and Peas

These crops are all good-to-excellent hosts for the soybean cyst nematode. SCN can reduce the yields of these crops, although populations higher than those on soybeans are needed to cause losses equal to those on soybeans. At present, crop rotations and soil sampling appear to be the best method of control on these crops. Research is now in progress to determine sources of resistance, the economic threshold, and possible interactions with other disease organisms.

Table 1. Characterization of the Known Races of the Soybean Cyst Nematode in the United States

	Reproduction on key varieties				
Race[a]	Pickett or Custer	Peking	P.I. 88788	P.I. 90763	Susceptible[b]
1	No	No	Yes	No	Yes
2	Yes	Yes	Yes	No	Yes
3	No	No	No	No	Yes
4	Yes	Yes	Yes[c]	Yes	Yes
5	Yes	No	Yes	No	Yes

[a]The numerical designation is based on chronological order of recognition, with Race 5 being the latest discovery.
[b]Any standard susceptible variety.
[c]Moderately resistant.

Table 2. Host Plants of the Soybean Cyst Nematode That Grow in Illinois

Crop and ornamental plants	Weeds
SOYBEANS, CULTIVATED AND WILD	HENBIT (*Lamium amplexicaule*)
BEANS, GREEN (SNAP), BUSH, KIDNEY, OR LIMA	HOP CLOVERS (*Trifolium* spp.)
LESPEDEZAS	CHICKWEED, COMMON (*Stellaria media*)
VETCH, COMMON, HAIRY, OR WINTER	CHICKWEED, MOUSEEAR (*Cerastium vulgatum*)
LUPINES, WHITE (ORNAMENTAL SPECIES)	MULLEIN, COMMON (*Verbascum thapsus*)
Clovers, crimson, scarlet, or alsike	SICKLEPOD (*Cassia obtusifolia*)
Sweetclover	Digitalis penstemon (*Penstemon digitalis*)
Birdsfoot-trefoil	Pokeweed (*Phytolacca americana*)
Crownvetch	Purslane (*Portulaca oleracea*)
Pea, garden	Bittercress (*Cardamine* sp.)
Cowpea or black-eyed pea	Rocky Mountain beeplant (*Cleome serrulata*)
Locust, black	
Bells of Ireland	Spotted geranium (*Geranium maculatum*)
Borage (*Borago*)	Toadflax, old-field (*Linaria canadensis*)
Canarybirdflower	Pigweed, winged (*Cycloloma atriplicifolium*)
Caraway	Vetch, American, Carolina, or wood (*Vicia micrantha*)
Chinese lanternplant	
Coralbells	Burclover or toothed medic (*Medicago* sp.)
Cup-flower	Dalea (*Dalea alopecuroides*)
Delphinium	Milkvetch, Canadian (*Astragalus canadensis*)
Foxglove	
Geranium	Beggars weed or tick clover (*Desmodium nudifolorum, D. marilandicum, D. viridiflorum*)
Geum	
Horehound, common (*Marrubium vulgare*)	
Poppy	Corn cockle (*Agrostemma githago*)
Sage	Hogpeanut (*Amphicarpa bracteata*)
Snapdragon	Milkpea (*Galactia volubilis*)
Sweet basil	Wildbean (*Strophostyles helvola*)
Sweet pea	
Verbena	

Entries in capital letters indicate highly susceptible hosts.

Table 3. Effect of Crop Rotation on Soybean Cyst Nematode (SCN) and Yield of Soybeans Resistant and Susceptible to SCN

Rotation by year[a]				Rotation by host for Race 3[b]				SCN per 100 cc. of soil, 1980		Yield, 1980
1977	1978	1979	1980	1977	1978	1979	1980	Cysts	Viable eggs and larvae	(bu/A)
soy(S)	soy(S)	soy(S)	soy(S)	H	H	H	H	57.5	256.9	20.4
soy(S)	corn	soy(S)	soy(S)	H	NH	NH	H	31.6	315.9	25.6
soy(S)	corn	corn	soy(S)	H	NH	NH	H	12.4	212.5	26.2
soy(S)	soy(R)	soy(R)	soy(R)	H	NH	NH	NH	3.4	1.4	24.3
soy(S)	corn	soy(R)	soy(R)	H	NH	NH	NH	1.4	18.7	27.2
soy(S)	corn	corn	soy(R)	H	NH	NH	NH	5.3	0	24.1

[a](S) = SCN-susceptible variety Union. (R) = SCN-resistant variety Franklin.
[b]H = SCN host. NH = Not a SCN host.
Data: Fayette County, 1980, Jacobsen, Pepper, Hirrel, and Melton.

Table 4. Comparison of Yields of Soybean Varieties Resistant and Susceptible to Soybean Cyst Nematode in Illinois[a]

Variety	Yield (bu/A) in soybean cyst nematode infested test locations: Yale, Jasper Co.	Mt. Vernon, Jefferson Co.	Sidney, Champaign Co.	Yield (bu/A) in test locations not infested with soybean cyst nematodes: Eldorado, Gallatin Co.	Belleville, St. Clair Co.	Urbana, Champaign Co.
Williams 82	9.5	25.8	--	48.4	56.4	51.3
Cumberland	5.6	30.6	--	50.6	57.5	56.3
Pella	8.1	23.1	--	50.2	55.7	53.1
Century	4.2	--	--	45.9	49.3	56.1
Union	15.5	29.2	--	50.9	--	--
Fayette	31.7	34.8	52.0	46.5	50.8	50.2
Franklin	26.0	30.6	--	42.0	--	--
Wells II	--	--	44.7			
Williams 79	--	--	44.6			

[a]Data from Dr. R.L. Bernard, Dr. G.R. Noel, and Dr. D.I. Edwards, USDA, 1981.

Table 5. Public Soybean Varieties Resistant to Races of the Soybean Cyst Nematode

Variety	Maturity group	Source of resistance	Race resistance
Fayette	III	PI 88788	1, 3, and 4
Franklin	IV	Peking	1 and 3
Custer	IV	Peking	1 and 3
Forrest	V	Peking	1 and 3
Bedford	V	Peking and PI 88788	1, 3, and 4
Nathan	V	Peking and PI 88788	1, 3, and 4

Table 6. Performance of Registered Nematicides against the Soybean Cyst Nematode in Illinois, 1968-1978

Chemical and location	Product (lb./A)	Years tested	Average yield (bu./A)		
			Treated[a]	Untreated[a]	Resistant varieties[a]
FURADAN 10G					
Franklin Co.	20 band	1975, 1980	32.4	25.4	37.0
MOCAP 10G					
Franklin Co.	25, 30 band	1968, 1976	23.4	22.4	27.7
NEMACUR 15G					
Franklin Co.	7.3 band	1977, 1978	22.6	20.9	30.4
Vermilion Co.	7.3 band	1977, 1978	41.9	37.2	...
Franklin Co.	14.5 band	1975, 1978, 1979, 1980	30.6	27.9	33.8
Vermilion Co.	14.5 band	1977, 1978, 1979, 1980	35.4	31.7	33.0 (36.4)[b]
Franklin Co.	29 band	1974, 1975, 1979, 1980	29.7	26.1	35.2
Vermilion Co.	29 band	1979, 1980	32.4	28.9	33.0 (36.4)[b]
TEMIK 15G					
Franklin Co.	7 in-furrow	1980, 1981	31.3	27.2	...
Vermilion Co.	7 in-furrow	1980	35.3	26.6	...
Franklin Co.	10 band	1978, 1979, 1980	28.6	25.0	28.9
Vermilion Co.	10 band	1978, 1979, 1980	37.1	30.3	33.0 (36.4)[b]
Franklin Co.	14.0 band	1977, 1978, 1979, 1980	30.4	26.4	31.3
Vermilion Co.	14.0 band	1978, 1979, 1980	40.3	30.3	33.0 (36.4)[b]
Franklin Co.	20 band	1976, 1977, 1979, 1980	35.7	29.0	31.6
Vermilion Co.	20 band	1977, 1979, 1980	41.6	33.0	33.0 (36.4)[b]

[a]Treated and untreated varieties for Franklin County tests were Clark 63(1968-1974), Williams (1977-1978), Cutler 71 (1975-1976), and Mitchell (1979-1980). Resistant varieties for Franklin County tests were Custer (1968-1977) and Franklin (1977-present). Treated and untreated varieties for Vermilion County tests were Amsoy 71 (1977-1979) and Wells II in 1980. The resistant variety used in Vermilion County tests was Franklin.

[b]The yield of maturity group II SCN-resistant breeding line.

Data: D.I. Edwards. USDA.

Table 7. Effect of High and Low Fertility on Average Yields of the Soybean Varieties Franklin and Union in the Presence of Race 3 of Soybean Cyst Nematode[a]

Variety	Yield (bu/A) High fertility	Yield (bu/A) Low fertility
Franklin (resistant to Race 3)	26.3	19.5
Union (susceptible to Race 3)	21.5	14.1

[a]Fayette Co., 1978-1980, Jacobsen, Pepper, Hirrel, and Melton.

Table 8. Effect of Temik® Nematicide on Union and Franklin Soybean Yields Under High and Low Fertility[a]

Variety	Yield (bu/A) with high fertility[b]		Yield (bu/A) with low fertility[c]	
	Temik[d]	No Temik	Temik[d]	No Temik
Franklin	31.0	28.7	24.4	22.3
Union	26.1	21.8	24.4	12.0

[a]Fayette Co., 1979, Jacobsen, Pepper, Hirrel, and Melton.
[b]High Fertility: P_1 Bray = 51; K = 263, pH = 6.2
[c]Low Fertility: P_1 Bray = 28; K = 94; pH = 6.5
[d]Temik 15G at 14.0 lbs. product per acre.

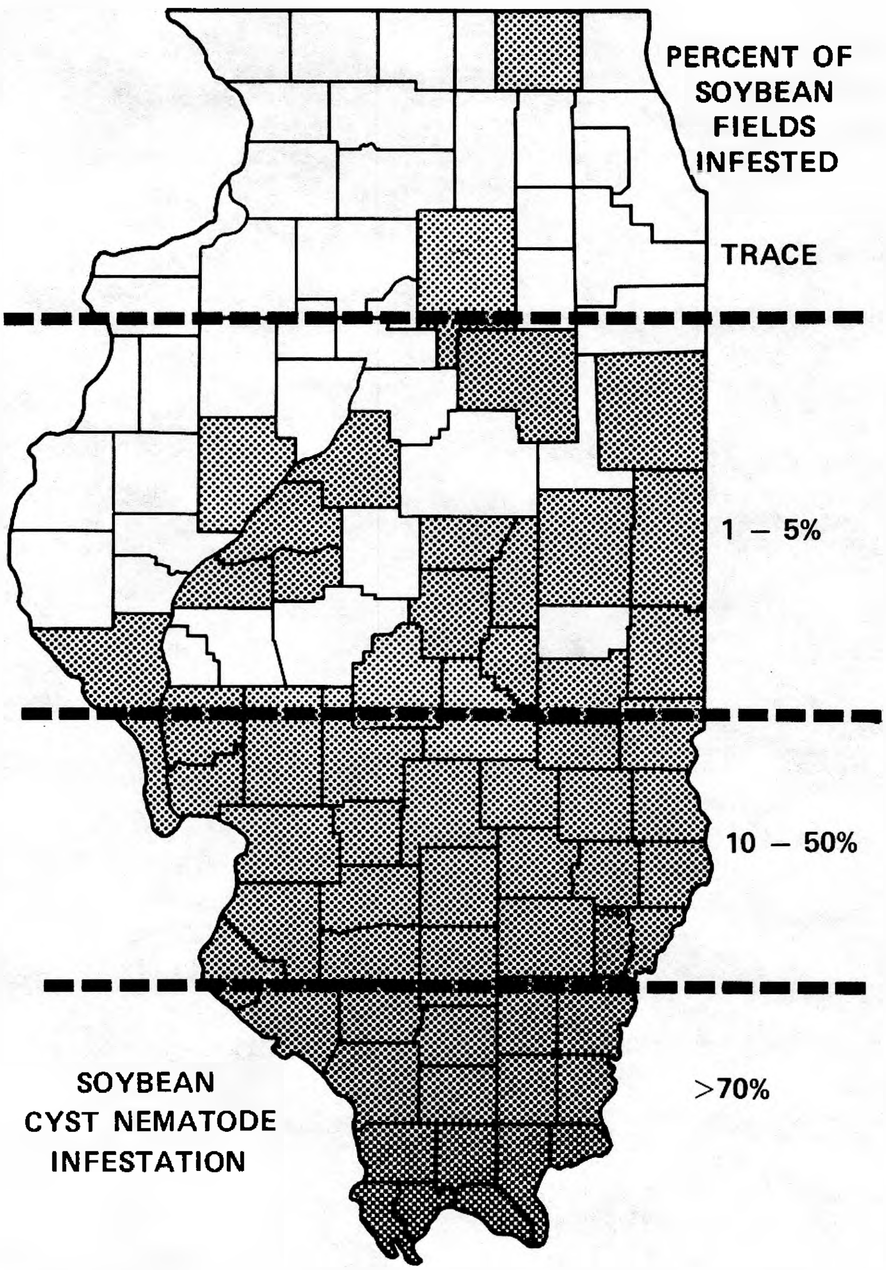


Figure 1. Illinois counties with known infestations of the soybean cyst nematode as of November 1, 1981.

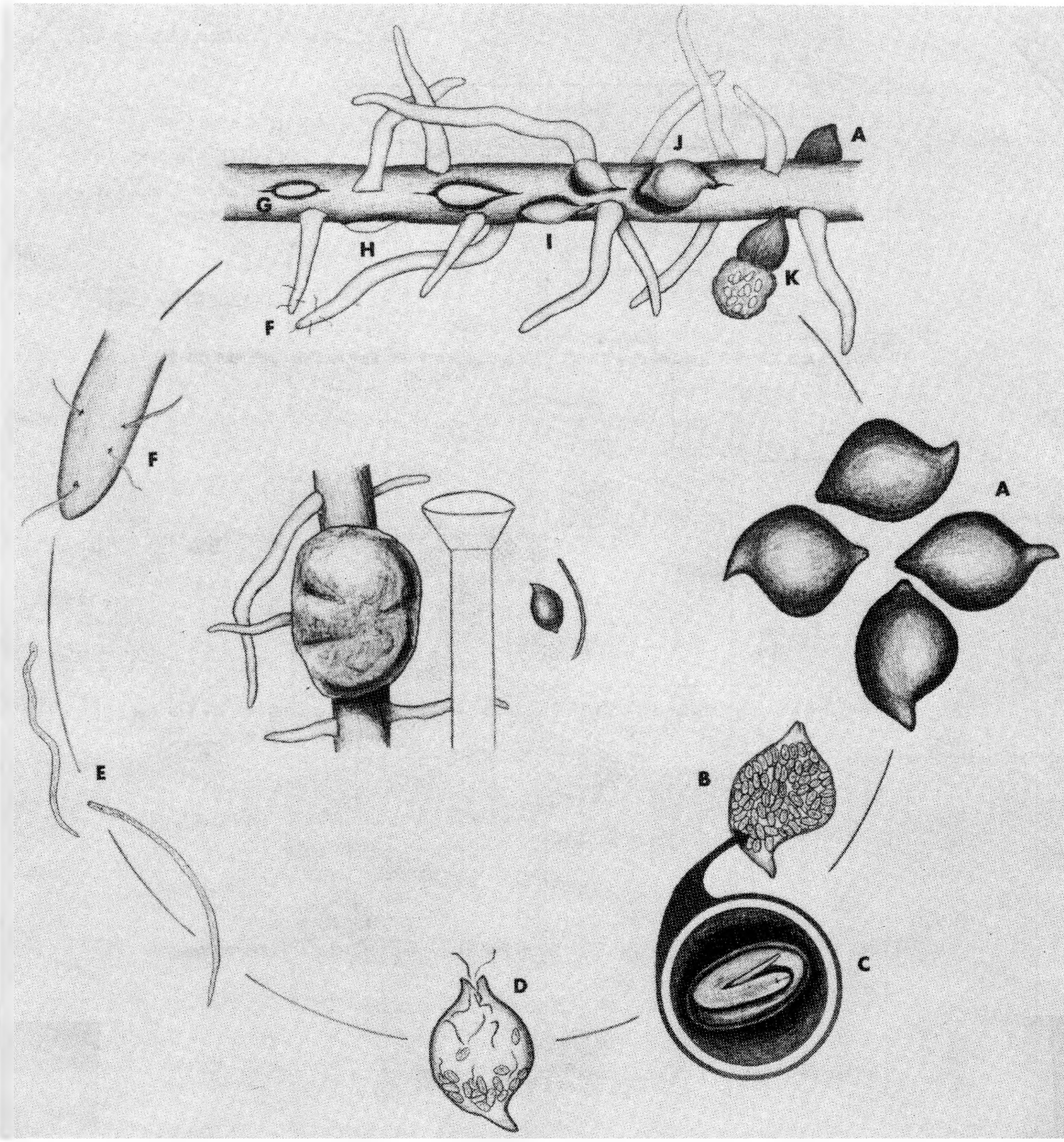


Figure 2. Disease cycle of the soybean cyst nematode. Brown, lemon-shaped cysts (A) overwinter in the soil. The cysts are filled with eggs (B). Each viable egg contains a fully developed second-stage larva (C). When temperature and moisture are favorable, the larvae hatch and emerge from the cysts (D). The larvae (E) move about freely in the soil before invading young roots by direct penetration (F). About 9 to 12 days after infection, the females become flask-shaped and split the root surface (G). They are pearly-white at first (H), turning pale-yellow to yellowish-brown as they mature (I). The females finally become almost entirely exposed through the root surface (J). A jellylike mass, in which some eggs are deposited, is extruded (K). The eggs in the matrix may hatch immediately with the emerging second-stage larvae ready to cause new infections. The cycle is completed when the female carcass, containing most of the 200 to 600 eggs, turns into a tough brown cyst (A) that may persist in the soil for many years. Approximately 21 to 24 days are required for the completion of the life cycle. To show the degree of magnification, a nodule of nitrogen-fixing bacteria, the head of a common pin, a cyst, and an adult male nematode are shown in the center.

Leaf Rust of Wheat

M.C. Shurtleff, B.J. Jacobsen, and W.L. Pedersen

Leaf rust of wheat is caused by the fungus *Puccinia recondita* f. sp. *tritici* (formerly *P. rubigo-vera* f. sp. *tritici* and *P. triticina*). During some years in Illinois, leaf rust has caused more damage than any other wheat disease. Loss estimates for a continuous 11-year period ranged from 0.4 to 17 percent (average, 11 percent). The annual reduction in potential yield was estimated at 4,743,000 bushels (per Illinois Natural History Survey Circular 48), representing an average annual loss of over $9 million to Illinois farmers for the 11-year period.

In recent years, the widespread use of rust-resistant varieties of winter wheat has substantially lowered the losses caused by leaf rust. However, in 1982 the widespread occurrence of new races capable of attacking these resistant varieties resulted in yield losses of nearly 20 percent.

The disease reduces the number of kernels per head, as well as the size of the kernels. Grain from severely rusted plants is also lower in test weight and protein content. Farmers usually underestimate the losses from leaf rust because the disease never destroys an entire Illinois crop and seldom causes severe shriveling of the grain.

Some leaf rust occurs in the state every year, but variations in the weather and the amount of rust inoculum (primarily summer spores or urediospores) overwintering in the southern states cause large year-to-year differences in rust development. A parasite of the rust fungus itself may develop some years, reducing the inoculum (urediospores) and thus the losses due to rust. With susceptible varieties, the yield loss is severe when rust infections occur early and continue until the crop is mature. During autumn in some years, severe infection may occur on winter wheat. This infection not only weakens the plants and reduces their root growth, but also lessens their value for forage.

The disease is worldwide, being most prevalent and serious where spring wheats mature late, as in the upper Midwest and Canada. The leaf rust fungus is a weak parasite on certain barley varieties and some species of goatgrass (*Aegilops*) and wheatgrass (*Agropyron*). Infections on these grasses as well as on *Anchusa*, *Anemonella*, and *Isopyrum* are relatively unimportant as sources of inoculum for wheat.

Other "form species" (f. sp.) of *Puccinia recondita* include:

- *P. r. agropyri*, which attacks wheatgrasses and wild ryegrasses in the Rocky Mountains area. Buttercup, clematis, columbine, larkspur, and other members of the Ranunculaceae are alternate hosts.
- *P. r. agropyrina*, which is similar to *P. r. agropyri* but found outside the Rocky Mountains area.

- *P. r. apocrypta*, which infects wheat and wild grasses and has waterleaf and mertensia as alternate hosts.
- *P. r. impatientis*, which is found on redtop and related grasses and has touch-me-not as the alternate host.
- *P. r. secalis*, which attacks rye with bugloss as the alternate host.

Symptoms

Small (up to 1.5 mm.), round-to-oval, raised, orange-red, dusty pustules or sori are scattered or clustered mostly on the upper surface of the leaves and leaf sheaths of susceptible wheat varieties. Each pustule contains many thousands of microscopic, orange-red urediospores. Rust usually starts on the lower leaves and gradually progresses up the plant to the flag leaf. Some sori may also develop on the stems (culms), and occasionally on the awns and glumes of the head. As the season progresses, the pustules become more and more numerous until 30 to 50 percent or more of the total leaf area may be destroyed by hundreds of orange-yellow rust pustules. A circle of small pustules may ring a large, older pustule.

Leaf rust is easily distinguished from stem rust (see *Report on Plant Diseases* No. 108) by the smaller size and orange-red color of the sori, plus the lack of conspicuous, jagged fragments of wheat epidermis adhering to the sides and ends of the pustules.

As the wheat matures, other dark gray-to-black, flattened pustules (telia) of about the same size develop in large numbers mostly on the undersides of the leaves, leaf sheaths, and even the culms. These glossy, black, subepidermal telia contain the winter spores (teliospores) and usually do not rupture the epidermis. The teliospore stage does no damage to the wheat crop. Teliospores may not be produced where plants become infected near maturity.

Disease Cycle

Unlike stem rust of cereals and grasses and crown rust of oats (see *Report on Plant Diseases* No. 109), the primary alternate host, Meadowrue (*Thalictrum* spp.), of wheat leaf rust fungus does NOT grow in Illinois and is not important in any area of the United States. The black teliospores are functionless in our country, and for all practical purposes the leaf rust fungus is limited to the urediospore stage. The urediospores endure low temperatures and usually overwinter in the southern states and Mexico on actively growing wheat. In mild winters the leaf rust fungus may survive as mycelium within leaves of fall-sown or volunteer wheat in Illinois. The typical orange-red pustules are then produced in early spring.

Urediospores produced on wheat grown in the southern states and Mexico are carried progressively northward into Illinois by the wind. They settle on the wheat plants and, when moisture is present, germinate and infect within six to eight hours. Once established under favorable conditions [frequent heavy dews, light rains, high humidity, and a temperature of 59° to 77° F. (15° to 25° C) with an optimum of about 70° F. (21° C)], a new generation of urediospores may be produced every 7 to 14 days. The disease spreads by windblown spores from plant to plant and from field to field until the crop matures.

The migration is reversed in the fall. Urediospores are blown southward, where they cause infections on winter wheat. The leaf rust fungus thus survives the winter in the orange-red urediospore stage or as mycelium within the wheat leaves.

Physiologic Races

Like most cereal rusts, the wheat leaf rust fungus is specialized into numerous physiologic races that can only be identified by their reactions on certain wheat varieties called differentials. More than 150 races are known. Wheat varieties may be immune to certain physiologic races of leaf rust, resistant to groups of races, and completely susceptible to still others. No wheat variety is highly resistant or immune to ALL known races. Luckily, only a few races are abundant and widely distributed in Illinois during any one year.

As new virulent races of rust build up, wheats that were formerly immune or highly resistant may become susceptible. For example, the soft winter wheat varieties Abe, Arthur, Arthur 71, and Oasis have recently become susceptible to new races. To meet this challenge, wheat breeders and plant pathologists are constantly working to incorporate rust resistance--covering more and more races--into new crosses, selections, and varieties. The battle between the rust fungi and the wheat breeders and plant pathologists is a continuous one.

Control

1. Sow seed of leaf rust-resistant wheat varieties adapted to your locality (Table 1). Follow the CURRENT recommendations made by Extension Agronomists at the University of Illinois, as given in the *Agronomy Handbook*, and by your County Extension adviser.
2. Sow winter wheat after the hessian fly-free date at the recommended rate and time for your locality. Sow spring wheat as early as possible. Plant in fertile, well-prepared soil. Where moderate or greater amounts of nitrogen have been applied to wheat without adding sufficient potassium and phosphorus to soils deficient in these elements, the possibility of severe rust attack is increased. Fertilizer use should be based on a soil test. Following the recommendations given in the soil test report should make it possible to increase yield WITHOUT increasing the susceptibility of the crop to leaf rust.
3. An aerial application of a foliage-protecting fungicide may be warranted if:

   a. The yield potential and value of the crop is high.
   b. The wheat variety is susceptible to leaf rust and/or Septoria diseases (see *Report on Plant Diseases* No. 105).
   c. Leaf diseases have an early start.
   d. The long-range weather forecast is for continued moist weather.

   The EPA-approved fungicides are PROTECTIVE AGENTS and must be applied to wheat foliage BEFORE infection occurs.

   A properly equipped aircraft--fixed wing or helicopter--is the best means of applying the fungicide to the crop. It is important to select an aerial operator who is familiar with disease control and whose aircraft is equipped to do the job. Proper application requires five gallons of water per acre to cover the foliage uniformly. The approved and suggested fungicides for use on wheat include:

   a. Maneb and zinc ion or mancozeb (sold as Dithane M-45, Manzate 200 Fungicide, Vancide Maneb Flowable, Amazin Zinc Enriched Maneb 80 Fungicide, Sup'-r'Flo Maneb Flowable, etc.) *and*

Table 1. Disease Reactions of Wheat Varieties Suggested for Growing in Illinois

Variety*	Recommended area of state[a]		Stem rust	Leaf rust	Loose smut	Septoria	Powdery mildew	Soil-borne mosaic	Barley yellow dwarf	Spot blotch	Pyrenophora	Wheat streak mosaic	False black chaff
Spring													
Era		N	R[b]	S[c]	MR	MS	MS			MR	MS		
Olaf		N	MR	MR	S								
Winter	*(Type)*												
Abe	(Soft)	N,C,S	R	S[c]	MS	S	MS	R	MS				R
Argee	(Soft)	N	R	S	MR		MR	R	MR				
Arthur	(Soft)	N,C,S	R	S[c]	MS	S	MS	R	MS				R
Arthur 71	(Soft)	N,C,S	R	S[c]	MS	MS	MS	R	MS				R
Auburn	(Soft)	N,C,S	R	R	MR	R	MR	R	MS				
Beau	(Soft)	N,C,S	R	MS	MS	MR	MS	R	MS				R
Caldwell[d]	(Soft)	N,C,S	R	MR	MR	MS	MR	MR	MR				
Centurk	(Hard)	N,C	MR	MS	MR	S	S	MS	MR		MR	S	
Hart	(Soft)	N,C,S	S	S[c]	R	MR	VS	R	MR				
Oasis	(Soft)	N,C,S	R	S[c]	MS	MR	MS	R	MS				R
Parker	(Hard)	N,C	S	MR	MS	MS	S	S	MS				MR
Pike	(Soft)	N,C,S	S	S	MR	MS	S	MR	MR				
Roland	(Soft)	C,S	R	S[c]	MS	S	MS	R	MS			MS	
Roy	(Soft)	S	S	MS			MR	R	MR				
Scotty	(Soft)	C,S	R	MR		MR	R	R	MS				
Sullivan[d]	(Soft)	N,C,S	R	MR[c]	MR	MR	MS	R	MS				R
Tyler	(Soft)	S	S	S			R	R	MR				

*Note: Several private varieties have high yield potentials and are widely planted. Growers should contact seed company representatives for information on disease resistance.

[a]Area of Illinois where variety is recommended: N = northern; C = central; and S = southern.

[b]Average disease reaction: R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; Blank = no information or disease is not important.

[c]Susceptible to new races that are virulent on *Lr* 9 and very common throughout the central United States in 1981 and 1982. Era is susceptible to nearly all leaf rust races as a seedling but has adult plant resistance that normally prevents leaf rust development on the flag leaf.

[d]Moderate resistance to Take-all.

b. Zineb (sold as Dithane Z-78, Ortho Zineb Wettable, Black Leaf Sheen, Niagara Zineb 75 Wettable, Stauffer Zineb 75-W, Chipman Zineb, Science Zineb Fungicide, Aceto Zineb-75, Acme Zineb 75W Fungicide, Sherwin-Williams Zineb, Pennwalt Zineb W-75, E-Z-Flo Zineb 75, Patterson's Zineb Wettable Powder, Chempar Zineb 75WP, Miller Zineb 75%, BASF Zineb 80 WP, etc.)

(Note that mention of a trade name or proprietary product does not constitute warranty of the product and does not imply approval of this material to the exclusion of comparable products).

Apply mancozeb or zineb at the rate per acre of 1-1/2 to 2 pounds of wettable powder in 5 gallons of water. Be sure to read the label and follow all directions. It is advisable to add a commercial spreader-sticker (surfactant) to the spray mix.

The time of application is critical, varying from area to area and season to season. Normally, the first spray is made to wheat when the head is beginning to emerge from the boot in a fourth of the plants. The second spray should follow 9 or 10 days later. If the leaf rust and/or Septoria diseases appear before heading, move the first spray up about a week. IT IS IMPORTANT TO KEEP THE FLAG LEAF AS DISEASE-FREE AS POSSIBLE UNTIL AFTER THE KERNELS HAVE FILLED.

For Successful Fungicide Application

1. Grow only recommended wheat varieties (see Table 1).
2. Watch the stage of growth and check for early disease symptoms.
3. Spray where there is a potential for high yields.
4. Make arrangements with your aerial applicator as early as possible.
5. Be sure the aircraft can apply five gallons of water per acre in a UNIFORM spray pattern.
6. Make two applications of a mancozeb or zineb fungicide, at 1-1/2 to 2 pounds per acre, PLUS a spreader-sticker. Apply the first spray at boot to early heading and the second one 9 or 10 days later.
7. Be sure to measure the yield and bushel weight.

M.C. Shurtleff and B.J. Jacobsen are Extension Plant Pathologists and W.L. Pedersen is Assistant Professor of Plant Pathology, Department of Plant Pathology, University of Illinois at Urbana-Champaign.

1983 Disease Management Guide for Commercial Vegetable Growers

The successful control of vegetable diseases requires an integrated program that includes the use of resistant varieties, disease certification programs, crop rotation, balanced soil fertility, weed and insect control, and proper crop culture as well as the selective application of fungicides, bactericides, or nematicides. Economical control depends on establishing an overall disease management system for the entire farm. Keeping careful records of the crops that have been planted, the problems encountered, and the pesticides used is important.

The information in this circular is updated annually. The grower should also consult the current versions of Circular 897, *Insect Pest Management Guide: Commercial Vegetable Crops and Greenhouse Vegetables,* and Circular 907, *Weed Management Guide for Commercial Vegetable Growers,* as well as Circular 1174, *Vegetable Varieties for Commercial Growers,* which contains information on disease resistance. Those circulars are revised each year.

Because many disease problems originate with seeds or transplants, growers should follow the seed treatment recommendations given in this circular or be sure to obtain planting material that is certified free of disease.

This publication presents the vegetable fungicide tolerances and application intervals for various crops as approved by the Food and Drug Administration (FDA) and the U.S. Environmental Protection Agency (EPA) as of October 1, 1982. The tables on the next two pages give (1) the tolerances in parts per million (ppm) and (2) the number of days between the last application at the normal rate and the harvest that will keep residues within the tolerances set by the FDA.

The listing of a chemical as approved for use on a particular crop does not mean that the Illinois Cooperative Extension Service or Agricultural Experiment Station recommends the use of the chemical for that crop. Our specific recommendations for disease control are given in the table entitled "Condensed Recommendations on Disease Management . . ."

In some instances a tolerance has been set but a definite interval has not been established. The absence of an interval for a particular crop in the listings does not necessarily mean that the fungicide may not be used on that crop. To ensure that the crop produced does not exceed the tolerance, the use of the fungicide would require a restriction such as "do not apply after first blooms appear" or "do not apply after edible parts form." This information appears on the product label.

In a few cases the interval and dosage have been established but the allowable residue concentration has not been determined. Again, this does not mean that the fungicide may not be used on the crops for which it is labeled. It does mean, however, that until the tolerance is established it must be considered as zero. These cases are reviewed each year, and some are cancelled when the chemical manufacturer supplies the EPA with additional data.

Growers must follow a program of disease control that will assure that the vegetables produced do not contain excessive fungicide residues. Vegetables marketed with residues exceeding the FDA tolerances may be injurious to consumers, may be confiscated, and may cause the grower to be brought to court.

Growers have nothing to fear from the law as long as they use fungicides and other pesticides according to the current label and only on the crops specified, in the amounts specified, and at the times specified. The prudent grower keeps a record of the products and trade names used, the percentage of active ingredients, dilutions, rates of application per acre, and dates of application.

This circular is revised each year. Be sure you are using the most recent copy.

Prepared by Barry Jacobsen, Department of Plant Pathology

Circular 1184

FUNGICIDE USES AND RESIDUE INFORMATION FOR VEGETABLES APPROVED BY THE EPA, OCTOBER 1, 1982[a, b, c]

Crop	Benlate,[d] 0.2-50 ppm	Captan (D) 2-100 ppm	Bravo, 0.1-15 ppm	Di-folatan, 0.1-15 ppm	Dyrene, 0.1-10 ppm	maneb, 4-45 ppm maneb with zinc salt	mancozeb[e] 0.1-15 ppm	zineb, 4-25 ppm
Asparagus	..	root dip	..	..	..	A[f]	A	A
Beans (dry, lima, snap)	(2-beans, 50-forage), 14, 28 on lima, B	pp, 0	(5-snap), 7, B(snap only)	..	..	(10), 0, 4 on limas or snap	..	(7), 7
Beet, garden	..	(2-root, 100-greens),0, pp	..	..	..	..	..	(7-roots); (25-tops), 7
Broccoli	..	pp	0	..	..	(10), 3, or trim and wash, 0	..	(7), 7
Brussels sprouts	..	pp	0	..	..	..	..	(7), 7
Cabbage	..	pp	0	..	..	(10), 7	..	(7), 7
Cantaloupe (muskmelon)	0	0, ph,[f] pp	0	0	0	(4), 5	(4-edible parts), 5	(4), 5
Carrot	..	0	0	..	..	0	(2), 7, B (tops)	(7), 7 (tops)
Cauliflower	..	pp	0	..	..	0	..	(7), 7
Celery	(3), 7	0, pb	(15), 7	..	0	(5), strip and wash, 14	0	(5), 14
Chinese cabbage	..	..	..	..	..	..	..	(25), 7
Corn, sweet and pop	..	(2-kernels plus cob), 10, B, pp	(1-kernels plus cob), 14, B[g]	..	..	0, B, C	(0.5-cob and kernels, 15-fodder and forage), 7	0, B, C
Cucumber	0	0, ph, pp	0	0	0	(4), 5	(4), 7	(4), 5
Eggplant	..	0, ph, pb	..	..	..	0	..	0
Endive, escarole	..	..	..	..	..	(10), 10, and wash	..	(10), 10
Fennel	..	..	..	..	..	..	(10), 7	..
Kale, collard	..	(2-greens), pp	..	..	..	(10), 10, and wash	..	(25-collard), 7; (10-kale), 10
Kohlrabi	..	pp	..	..	..	0	..	(7), halfgrown
Lettuce	..	0	..	..	..	10, strip and wash	..	(10), 10
Mustard greens	..	pp	..	..	..	(10), 10, and wash	..	(10), 10
Onion	..	(50-green, 25-dry),0, ph	(5-green), 14; (0.5-dry), 7	0	0	0	(0.5-dry), 7, D	(7), 7
Peas	..	(2-dry and succulent), pp	..	..	..	..	..	(7), 10
Pepper	..	0, pb, pp	..	..	..	0	..	0
Potato, Irish[f]	..	0, ph	0	0	0	0, C	0	0 and seed, C, pp
Pumpkin	0	0, pp	0	..	0	0	..	0
Radish	..	..	..	..	..	..	..	0
Rhubarb (greenhouse)	..	0	..	..	..	0	..	..
Spinach	..	0, pp	..	..	..	(10), 10, and wash	..	(10), 10
Squash	0	0, pp	0	..	0	(4), 5	(4), 5	(4), 5
Sugar beet[f]	(0.2-roots, 15-tops), 21	0	..	..	..	(45-tops), 10, B, C; 14, no feeding restrictions	(2-roots, 65-tops), B, 14	..
Swiss chard	..	0	..	..	..	..	..	(25), 7
Tomato	0	0, pp	0	0[h]	0	(4), 5, F	5	(4), 5
Turnip, rutabaga	..	(2-greens and roots), pp	..	..	..	(10-tops, 7-roots), 7, and wash	..	(7-roots and tops), 7 (tops)
Watermelon	0	0, pp	0	0	0	(4), 5	(4-edible parts), 5	(4), 5

[a] No tolerances have been set for these fungicides on dill, horseradish, okra, parsley, and parsnip. Tolerance information is given in the table in parts per million within parentheses.
[b] The following abbreviations are used:
A = Postharvest application to ferns only or to young plantings that will not be harvested.
B = Do not feed treated tops or forage to livestock.
C = Do not use treated seed or seed pieces for feed or food.
D = Do not apply to exposed bulbs.
E = Do not apply after fruit buds form.
F = To avoid damage, do not use on tender young plants.
pb = Plant bed treatment.
ph = Postharvest spray or dip.
pp = Preplant soil treatment.
[c] Numbers in table that are not in parentheses indicate number of days between last application and harvest; 0 = up to harvest.
[d] Do not apply Benlate alone; always use in combination with mancozeb or other labelled protective fungicide such as Captan, Bravo, Dyrene, or maneb. Do not mix with Mertect or Topsin-M.
[e] Mancozeb is sold as Dithane M-45 and Manzate 200.
[f] Tolerances are not needed for pesticides applied only to the foliage and not translocated to the tubers or roots.
[g] Do not apply if the crop will be used for processing.
[h] Machine harvest only.

LABEL INFORMATION ON FUNGICIDES OF LESS GENERAL USE

Fungicide (tolerance)	Crops and use restrictions
Botran (5-20 ppm)	**Beans** (snap) — white mold, 2 days to harvest. Do not feed forage to livestock. **Greenhouse tomato** — to harvest. Do not drench seedlings or newly set transplants. **Carrot** — postharvest dip or spray, see label. **Garlic, onion** — soil application before seeding or spray to soil around sets or bulbs. *Do not plant spinach* as a followup crop in treated soil. **Leaf lettuce** (greenhouse) — 14 days[a] (do not apply to wilted plants or seedlings). **Head lettuce** — 14 days. **Celery** — 7 days. **Cucumber** (greenhouse) — see label. **Rhubarb** (greenhouse) — 3 days. **Potato** — 14 days (do *not* feed to livestock). **Sweet potato** — root dip and plant bed treatment. **Note:** Do not plant tomatoes as followup in treated soil. Don't use spent roots for food or feed. Postharvest spray or dip as directed. **Tomato** (greenhouse) — 3 days.
carbofuran (Furadan 10G)	**Corn** (sweet and pop) — nematodes. Apply in band or furrow at planting. **Cucumber**, melon, **squash, pumpkin** — apply in band at planting.
chloroneb (Demosan)	**Beans** — seedling diseases. Seed treatment or in-furrow spray at planting.
Copper fungicides[b]	
tribasic copper sulfate (Kobasic, Triangle, Tri-basic Copper Sulfate, etc.)	Bean, beet, **broccoli, Brussels sprouts, cabbage, cantaloupe, carrot, cauliflower, celery, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, pea, potato, pumpkin, radish, spinach, squash, tomato, watermelon.**
copper sulfate (many)	**Bean, broccoli, cabbage, cantaloupe, cassaba melon, cauliflower, celery, cucumber, honeydew melon, muskmelon, Persian melon, potato, pumpkin, radish, squash, tomato, watermelon.**
copper resinate (Citcop 4E, Cop-O-Cide, Emulsifiable Liquid Copper Fungicide)	**Bean, broccoli, cantaloupe, cauliflower, chinese cabbage, carrot, celery, cucumber, honeydew melon, lettuce, muskmelon, onion, pepper, pumpkin, squash, tomato, turnip, watermelon.**
copper ammonium carbonate (Copper-Count N)	**Bean, cabbage, carrot, crenshaw melon, celery, cantaloupe, cassaba melon, cucumber, honeydew melon, lettuce, muskmelon, pepper, Persian melon, potato, squash, tomato, watermelon.**
copper hydroxide (Kocide 101 and 404)	Bean, broccoli, **Brussels sprouts, cabbage,** cantaloupe, carrot, celery, **cucumber, honeydew melon, muskmelon, pepper, potato, pumpkin, squash, tomato, watermelon.**
copper oxychloride sulfate (COCS, Copro 50 and 53)	Bean, beet, broccoli, **Brussels sprouts, cabbage, cantaloupe, carrot, cassaba melon, cauliflower,** celery, crenshaw melon, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, pea, Persian melon, potato, pumpkin, spinach, squash, tomato, watermelon.
Bordeaux mixture (Acme Bordeaux mixture, Pattersons Bordeaux mixture, Bor-Dox, Ortho Bordo mixture, etc.)	**Asparagus, beans, beets, broccoli, Brussels sprouts, cabbage, carrot, cassaba melon, celery, collards, crenshaw melon, honeydew melon, horseradish, kale, mustard, pepper, rape, rutabaga, spinach, cress, cucumber, eggplant, honeydew melon, muskmelon, Persian melon, potato, pumpkin, radish, squash, tomato, turnip, watermelon.**
fenaminosulf (Lesan)	Cleared *only* for seed-treatment use on **beans, beets, corn, cucumbers, peas, spinach, sugar beets.** Do not use treated seed for food, feed, or oil. Slurry seed treatment for planting in light soils or soils high in clay or organic matter.
dinocap (Karathane)	**Cantaloupe (muskmelon), cucumber, honeydew melon, pumpkin, squash, watermelon** — 7 days. For control of powdery mildew only.
etridiazol (Terrazole, Truban)	Seed treatment: **Beans, peas, sugar beets.**
oxymal (Vydate)	**Potatoes** — nematodes. Apply before or at planting.
polyethylene polymer (Polyram) (0 ppm)	Potato, **sugar beet** — no time limitations. **Celery** — 14 days. **Cantaloupe, cucumber, tomato** — 5 days. Do *not* feed **sugar beet** tops to meat or dairy animals. **Celery** — strip, trim, and wash — 14 days. Postharvest application to **asparagus ferns.**
PCNB (Terraclor, Brassicol, Fungiclor) (0.1 ppm)	**Beans** — base of plants *before* blossoming, soil and seed treatment at planting, or foliar spray. Do *not* feed treated **Bean** vines to livestock. Do *not* apply after first bloom. **Broccoli, Brussels sprouts, cabbage, cauliflower** — transplant solution (¾ pint per plant) or row treatment before transplanting. **Pepper, potato, tomato** — soil treatment at or before planting. **Tomato** (greenhouse) — transplant solution (½ pt. of 0.2% per plant). **Garlic** — soil and seed treatment at planting.
streptomycin (0.25 ppm)	**Celery, pepper, tomato** — plant beds only (200 ppm spray); **Potato** — seedpiece treatment only (100 ppm dip or dust). Soak cut seed pieces less than 30 min. **Beans** — seed treatment for halo blight control. Do not use treated seed for food or feed.
sulfur, lime, and lime-sulfur	Exempt when used with good agricultural practices. See label.
thiabendazole (Mertect) (0.02-0.1 ppm)	**Sweet potato** — "seed" root treatment. Do not use treated pieces for food or feed. **Potato** — "seed" tubers only (1,500 ppm-20 sec. dip). Storage rot control.
thiophanate methyl (Topsin-M)	**Beans** — white mold and gray mold. Snap or dry beans, 14 days. Lima, 28 days. **Celery** — early and late blight, 7 days.
thiram, TMTD (0.5-7 ppm)	**Onion** — Furrow treatment. **Celery** — 7 days (strip, trim, and wash). **Sweet potato** — preplant root dip. **Tomato** — 0 days, for leaf spots and fruit rots. Seed treatment: **Beans, beets, broccoli, Brussels sprouts, cabbage, cantaloupe, carrot, cauliflower, collard, corn, cucumber, eggplant, endive, kale, kohlrabi, lettuce, okra, onion** (bulb, seed, and set), **peas, pepper, pumpkin, radish, spinach, squash, swiss chard, tomato, turnip, watermelon.** WARNING: Do not use treated seed for food, feed, or oil — 7 days.
triphenyltin (Du-Ter)	Carrot — Alternaria leaf spot and late blight — 14 days. **Potato** — early and late blight. May be applied through irrigation systems (solid set or center pivot only).
terbufos (Counter 15G)	**Corn** (sweet and pop) — Apply in band or furrow at planting.

[a] Number of days between last application and harvest.
[b] There are many other copper materials, but these are most widely available and labeled for use on vegetable crops. Exempt from tolerance if used with good agricultural practices; not exempt if used at the time of harvest or after harvest. See label.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT FOR DISEASES OF COMMERCIAL VEGETABLE CROPS FOR 1983

Vegetable	Disease management practices
Asparagus	
Crown or root rots, seedling blights, and wilt	No resistant varieties are available for control of these diseases. Treating the crowns with captan or mancozeb may aid in control. These diseases are best managed by good asparagus culture. Provide optimal soil fertility, and weed, insect and rust control. Avoid excessive cutting.
Rust, other leaf and branchlet blights	Grow rust-resistant varieties. Apply zineb, maneb, mancozeb, or Polyram to nonharvested fields up to August 15 and to harvested fields after harvest only. Applications should be made on 7- to 10-day intervals.
Beans (snap, dry, wax, and lima)	
Most diseases	When possible, use rotations of 2-3 years between bean crops.
Seed decay, damping-off, seed-borne stem blights, and root rots	Plant only western-grown, certified seed in a seed bed that is warm (60°-65° F.) and well-prepared. Seed treatment with thiram, captan, captan plus fenaminosulf, Terrazole, or chloroneb plus insecticide is suggested. In-furrow sprays of chloroneb may be helpful for early season root-rot control.
Root rots	Maintain optimal soil fertility. Utilize crop rotations of 2-3 years.
Bacterial blights	Plant only western-grown, certified seed. Utilize crop rotations of 2 to 3 years. Avoid cultivating when beans are wet. Streptomycin may be added to seed treatment fungicide/insecticide. Field applications of 2-3 pounds of fixed copper per acre will provide good control of brown spot and halo blight, only moderate control of common or fuscous blight.
Downy mildew and syringe blight (brown spot) on lima beans	Make early and weekly applications of maneb plus fixed copper. Eliminate lilac and wild cherry from field borders.
Rust, anthracnose, and other fungal leaf, pod, and stem diseases	Utilize crop rotations of 2-3 years. Apply maneb, zineb, or Bravo at 7- to 10-day intervals. Rust-resistant varieties are available for some types of beans. Sulfur can also be used but may be phytotoxic at high temperatures.
White mold, gray mold	Apply Benlate, Botran, or Topsin-M first at initial to 25 percent bloom and again at full bloom. Botran may be used on snap beans only.
Virus diseases	Plant varieties with resistance to bean common mosaic, NY15 strain of common mosaic, and bean yellow mosaic.
Soybean cyst nematode	Rotate 2-3 years with corn, small grains, alfalfa, red clover, or other nonhost crop. Do not include soybeans in the rotation.
Beets (garden and sugar), Swiss chard	
Seed rot, damping-off, and seed-borne leaf spot	Sow in a well-prepared seed bed. Treat seed with captan or thiram. Make sure boron levels are adequate.
Cercospora leaf spot	Apply zineb or fixed copper weekly at the first sign of disease.
Crucifer crops (broccoli, Brussels sprouts, cauliflower, cabbage, chinese cabbage, collards, kale, kohlrabi, mustard, radish, rutabaga)	
Seed rot, damping-off, black rot, blackleg	Sow only western-grown, hot water-treated seed. Seed also should be treated with thiram or captan. Place seed beds where no crucifer has grown for 4 years or more and where water will not drain from fields recently planted to crucifers.
Wirestem (*Rhizoctonia*)	Incorporate PCNB-captan in upper 3 inches of soil before planting or drench after planting.
Clubroot	Apply PCNB (Terraclor 75) in transplant water.
Black rot and blackleg	Use a crop rotation of 3-4 years or more. Use only hot water-treated seed. Use care in the selection of plant bed sites. Be sure no drainage occurs to seed bed from old plantings. Control wild mustard and other cruciferous weeds. Purchase only certified, disease-free transplants. Do not dip transplants before planting. Sprays of fixed copper may help control black rot. Bravo applied to control downy mildew may also help control blackleg. Some cabbage varieties resistant to black rot are available. Losses are generally lower where direct seeding is used.
Downy mildew, Alternaria leaf spot, and other fungal leaf diseases	Apply maneb, zineb, or Bravo on weekly intervals. Start applications in seed bed or when plants are young.
Tipburn	Plant resistant varieties.
Fusarium yellows	Plant yellows-resistant varieties.
Radish black root	Plant resistant varieties.
Carrots, Parsnips	
Seed rot, damping-off, Cercospora leaf spot, Alternaria leaf blight	Treat seed with captan or thiram. Apply maneb, mancozeb, zineb, or Bravo on 7-10 day interval.
Aster yellows	Use insecticides to control leafhoppers that transmit the mycoplasma. Excellent early season leafhopper control is essential. Control must occur *before* leafhoppers feed.
Root-knot nematode	Fumigate mineral soils with D-D, Telone, EDB, or Vorlex. Do not use EDB where onions will be planted within 3 years, *or* practice a 3-year rotation with corn or some other nonhost crop with which broadleaf weed hosts will be controlled.
Parsnip canker	Spray with fixed copper at a 10-day interval in late season (August) until the tops die. Ridge soil over the shoulders.
Celery, Parsley	
Seed rot, damping-off, seed-borne leaf blights	Treat plant seed with hot water, then captan or thiram. If damping-off starts, spray 2-3 times, 5-7 days apart with zineb. Seed 2-3 years old is free of late blight.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Leaf blights and spots	Spray maneb, zineb, Benlate, Topsin-M, Dyrene, Bravo, or mancozeb at 7-10 day intervals.
Aster yellows and Root-knot nematode	(See the section on Carrots and Parsnips)
Corn (sweet and pop)	
Seed rot, seedling blights, seed-borne diseases	Plant seed treated with captan, thiram, or Vitavax-thiram and insecticide.
Goss' bacterial wilt	Use 2 to 3 year crop rotations when using susceptible corn (dent or sweet) varieties.
Stewart's disease	Control flea beetles with insecticide, or plant tolerant hybrids.
Smut	Plant tolerant hybrids.
Maize dwarf mosaic, Wheat streak mosaic	Control Johnsongrass and volunteer wheat. Plant wheat after the fly-free date. Some hybrids tolerate maize dwarf better than others, but no hybrids are highly resistant.
Helminthosporium leaf blights, anthracnose leaf blight	Spray mancozeb, Polyram, or Bravo when disease first appears. Crop rotation and clean tillage will help reduce disease risk.
Rust	Spray the same as for Helminthosporium blights or plant resistant varieties.
Nematodes	Apply carbofuran or terbufos at the time of planting.
Vine Crops (cucumbers, muskmelons (cantaloupe), pumpkins, squash, and watermelons)	
General	Use a crop rotation of 3-4 years. Grow resistant varieties whenever possible.
Seed rot, damping-off, seed-borne diseases	Plant only certified, western-grown seed treated with captan or thiram. Damping-off can be treated with a captan drench.
Bacterial wilt	Provide season-long control of striped and spotted cucumber beetles. Start as the plants emerge.
Anthracnose, scab, blossom blights, gummy stem blight, or black rot	Grow resistant varieties whenever possible. Spray weekly with maneb, zineb, Bravo, Dyrene, Difolatan, or Benlate.
Downy mildew, Alternaria leaf blight	Grow resistant varieties whenever possible. Maintain ample but *not* excessive nitrogen fertility. Apply maneb, zineb, mancozeb, Dyrene, Bravo, or Difolatan on a weekly schedule.
Fruit spots and rots	Maintain fungicide schedule as for anthracnose through the season. Avoid harvest injuries.
Fusarium wilt	Grow resistant varieties.
Angular leaf spot	Apply fixed copper sprays in combination with zineb, maneb, or mancozeb. Start applications early in the season. Practice crop rotations of 3-4 years. Resistant cucumber varieties are available.
Powdery mildew	Apply Karathane WD at the first sign of disease and again 10 days later. Where Benlate or Bravo are applied to control other diseases, mildew will be controlled well. Plant resistant varieties where possible.
Mosaics	Control aphids and beetles in the field. Control broadleaf weeds around field borders. Plant only mosaic-resistant cucumbers.
Root-knot nematode	Fumigate with Vapam or Vorlex in the fall before planting or use carbofuran at planting.
Eggplant	
Seed rot, damping-off, seed-borne diseases	Plant hot water-treated seed when possible. Treat the seed with captan or thiram. Damping-off can be controlled with a captan drench.
Phomopsis blight, Alternaria leaf spot, Cercospora leaf spot, and anthracnose	Spray plants weekly with maneb, zineb, or captan at first sign of disease or when first fruits are half sized.
Verticillium wilt, nematodes	Fumigate the soil with Vapam, Vorlex, or methyl bromide plus chloropicrin.
Horseradish	
Leaf spots	Apply fixed-copper fungicides. Start when conditions are wet or dews are heavy. Continue until a killing frost occurs.
Brittleroot	Plant clean sets. Control leafhoppers.
Verticillium wilt	Fumigate the soil before planting with Telone C.
Lettuce, Endive	
Seed rot, damping-off, Gray mold	Treat seed with captan. In the field or seed bed, work Botran into the soil before planting and spray Botran after thinning or transplanting and again as necessary. Ferbam or zineb can be used as drenches to control damping-off.
Aster yellows	Control leafhoppers throughout the season. Early season control is most important.
Rhizoctonia bottom rot, Sclerotinia drop	Plant on beds and deep plow when possible. Botran applications as previously described may help.
Gray mold, white rust, downy mildew	Apply ferbam, maneb, or zineb at 5- to 7-day intervals.
Okra	
Seed rot, damping-off	Treat seed with captan or thiram.
Fusarium wilt or Verticillium wilt	Fumigate soil with Vorlex, Vapam, or methyl bromide plus chloropicrin.
Onions, garlic, leek, chives	
Smut, seed rot, damping-off	Treat the seed with captan or thiram. Use Methocel sticker to pellet the fungicide with seed. Use 1 pound of active ingredient to 20 pounds of seed for set onions; 6 pounds of active ingredient to 8 pounds of seed for bulb onions.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (continued)

Vegetable	Disease management practices
Blast, downy mildew, Alternaria purple blotch, Botrytis neck rot	Apply maneb, zineb, mancozeb, Difolatan, Dyrene, or Bravo on a weekly schedule. Begin spraying with first ozone alert. Continue until harvest. Bravo has given superior control in research trials.
Bulb and stem nematode, Root-knot nematode	Fumigate with Telone or DD.
Fusarium basal rot	Avoid heavily infested fields. Grow resistant varieties.
Storage decays	Maintain excellent control of leaf diseases in the field. Maintain dry storage conditions.
Yellow dwarf mosaic	Control aphids. Keep old and new plantings as far apart as possible.
Peas	
Seedpiece decay, seed-borne seed-borne diseases	Plant western-grown seed treated with captan, thiram, fenaminosulf, or zineb plus insecticide. Graphite at 1 ounce per bushel may be added to reduce friction in the drill.
Root rot	Index production fields. Avoid planting in fields with an index of 75 or higher. In fields with a lower root rot index, dinoseb (Premerge 3) or trifluralin applied preplant incorporated will provide good to excellent control.
Fusarium wilt, near wilt, and virus diseases	Grow resistant varieties.
Powdery mildew	Apply lime-sulfur dust (4:6 ratio) at 30 pounds per acre when mildew first appears and temperatures are less than 80° F. Two applications a week apart will provide good control.
Fungal leaf spots and blights	Apply zineb weekly when necessary.
Peppers	
Seed rot, damping-off, and seed-borne diseases	Treat seed with hot water or a sodium hypochlorite (household bleach) soak, then use captan or thiram. The sodium hypochlorite soak will control seedborne bacterial spot. Use 1 part bleach to 3 parts water, soak 1 to 2 minutes. Use 1 gallon of bleach-water solution to 1 pound of seed. Rinse thoroughly before treating with fungicide.
Bacterial spot	Use crop rotations of 2-3 years, excluding small grains and tomatoes. Control broadleaf weeds in field borders. Apply copper plus streptomycin to seedlings. After transplanting, apply fixed copper plus maneb or mancozeb, on a 5- to 7-day interval. Purchase only certified, disease-free transplants. Planting peppers in narrow strips between early planted corn may help reduce spread during severe rain and wind storms.
Anthracnose, Cercospora leaf spot, other fungal leaf spots, and fruit rots	Apply maneb or zineb after first fruits form on a 5- to 7-day interval.
Verticillium wilt	Fumigate soil with Vapam, Vorlex, or methyl bromide plus chloropicrin.
Virus diseases	Grow resistant varieties. Control aphids and broadleaf weeds in and around fields. Plant only healthy transplants.
Potatoes (Irish)	
General	Purchase only certified seed. Seed-production fields should be inspected for virus, nematode, or fungal disease problems.
Seedpiece decay, seed-borne Verticillium wilt, and Blackleg	Treat seed with captan, maneb, or mancozeb. Keep seed storage at approximately 40° F. during the winter. In the spring, warm the seed to 60°-70° F. for 1.5-2 weeks before cutting. Streptomycin may be added to fungicide dusts to improve the control of bacterial diseases.
Scab	Plant resistant varieties. Do *not* apply manure or other organic matter immediately before the potato crop. Working PCNB into the top 4-6 inches of the soil at or before planting may help.
Storage rots	Store healthy, sound, unbruised potatoes. Maintain a proper storage environment. Apply Mertect 340F as a spray to unwashed tubers before storage. This will help control Fusarium dry rot.
Rhizoctonia	Use a Terraclor EC soil treatment.
Verticillium wilt	Practice crop rotation, use only seed free of Verticillium. Control root-knot and root-lesion nematodes. Soil fumigation with Vapam or Vorlex may be practical.
Nematodes	Where soil samples indicate damaging levels of nematodes, apply Temik or Vydate, or fumigate with Vapam, Vorlex, D-D, or Telone C.
Early blight and late blight	Apply maneb, mancozeb, Difolatan, Bravo, Polyram, Du-Ter, or Dyrene on 7- to 10-day schedule. Mainain an adequate supply of nitrogen throughout the season to provide good control of early blight.
Virus diseases and Purple-top wilt (Aster yellows)	Plant certified seed only. Control aphids and leafhoppers with insecticides.
Rhubarb (greenhouse only)	
Botrytis leaf rot	Apply after budding and at weekly intervals until harvest.
Crown and root rots	Plant only in well-drained soil. Maintain optimal soil fertility. Drench the crowns with fixed copper at 3 pounds per acre in the early spring and after harvest if crown rot is a problem.
Spinach	
Seed rot and damping-off	Treat seed with captan or thiram.
Downy mildew or blue mold, White rust, anthracnose, and other fungal leaf diseases	Grow resistant varieties or spray with captan, maneb, or zineb on a 5- to 7-day schedule starting before the plants begin to rosette.
Cucumber mosaic virus or blight	Grow resistant varieties.

CONDENSED RECOMMENDATIONS ON DISEASE MANAGEMENT (concluded)

Vegetable	Disease management practices
Sweet potatoes	
Black rot, foot rot, Fusarium wilt and scurf	Grow resistant varieties. Plant disease-free roots and use crop rotations of 3-4 years. Dip the roots or sprouts in Botran or Mertect 340F.
Storage rots	Fumigate storage crates and houses with formaldehyde. Use Botran as a postharvest dip. Store only healthy, blemish-free roots.
Nematodes	Plant resistant varieties. Use crop rotation. Temik, Mocap, or Dasanit may be used for chemical control.
Tomatoes (field)	
Seed decay, damping-off, and seed-borne diseases	Plant hot-water- or sodium-hypochlorite-soaked seed that has been treated with captan or thiram. See treatment for pepper seed.
Bacterial spot and bacterial speck	Purchase certified, disease-free plants. Use crop rotations of 2-3 years, excluding small grains. In the seed bed, spray with fixed copper plus streptomycin. After transplanting, spray with fixed copper plus mancozeb. Once established, bacterial spot is difficult to control.
Septoria blight, early blight, buckeye rot, gray leaf spot, and leaf mold	Apply maneb, mancozeb, Polyram, zineb, Dyrene, Bravo, or Difolatan on a 7- to 10-day schedule after the first sign of disease or after the first fruits form. Difolatan may be used only on machine-harvested fruit. A soil surface spray of Difolatan or maneb after the last cultivation will improve anthracnose control. Benlate may be use for Botrytis and Septoria control.
Blossom-end rot	Mulch plants or maintain uniform soil moisture. Applications of calcium nitrate starting when the fruits are grape size may reduce losses.
Verticillium wilt and Fusarium wilt	Grow resistant varieties.
Viruses	Take care to avoid infecting the seedlings. Start with virus-free seed. Control insects and broad-leaf weeds in and around fields. See greenhouse tomatoes below.
Tomatoes (greenhouse)	
Virus diseases	Start with hot water-treated seed. Do not allow the use of tobacco on the premises. Smokers should wash their hands with soap and hot water before working with plants. If possible, plant TMV-resistant hybrids. Control insects. Remove infected plants if possible.
Botrytis gray mold, leaf mold, and gray leaf spot	Avoid excessive humidity by heating and venting, especially at night during the late fall, early winter, and early spring. Spray weekly with Benlate, mancozeb, or Bravo *or* fumigate with Exotherm Termil.
Nematodes, root rots, and soil-borne TMV	Steam the plant beds.

GENERAL SUGGESTIONS ON FUNGICIDE APPLICATION

1. Cover the foliage uniformly. *Ground equipment* — Apply 75 to 125 gallons per acre at approximately 400 pounds per square inch of pressure. Lowering volumes and/or pressures may provide adequate coverage, but high-volume, high-pressure applications provide ideal coverage. Make sure the sprayer is functioning properly. Check the nozzles for cleanliness and wear. Boom, height, accuracy of pressure gauge, agitation, and calibration should also be checked. *Aerial application* — Apply recommended amounts of pesticide per acre in 3 to 5 gallons of water. Make sure nozzles are properly aligned and clean, so uniform application is achieved. Cover a swath no wider than is reasonable for the aircraft and boom being used. Spray only those fields which are suitable for aerial application. Avoid fields of irregular shape or topography, particularly if they are bounded by power lines, trees, or other obstructions.
2. Whenever possible spray when the air is still or when wind velocity is not excessive (less than 10 to 12 mph).
3. Avoid situations where pesticide drift may cause needless problems.
4. When it is compatible with the product label, use a spray adjuvant (surfactant). Some commonly available surfactants are: Colloidal Products X77 (liquid, non-ionic) spreader activator; Colloidal Products Multifilm L. (liquid); Colloidal Products Spray Modifier (liquid, non-ionic) spreader sticker; Millers Nufilm 17 liquid spreader sticker; Millers Nufilm P liquid spreader sticker; Allied Chemical Plyac (liquid) sticker; Rohm and Haas Triton B — 1956 (liquid, non-ionic) spreader sticker; Triton CS7, spreader-binder; and Du Pont Spreader Sticker (liquid) spreader sticker.

GENERAL SUGGESTIONS ON SOIL FUMIGATION

Follow the manufacturer's directions exactly. Fumigants work best in light, loose soils that are free of trash, clods, and lumps. Avoid recontaminating treated soil. It is best to apply fumigants during the fall before planting. In general, the soil temperature must be at least 55° F. at the 6-inch depth, with a time lapse of 21-28 days between treating and seeding. Some require gas-tight plastic covers.

Applying Herbicides Accurately

B.J. Butler and Loren E. Bode

There have been many advances in agricultural pesticides and the methods and machines used to apply them since the arrival of "modern" pesticides in the 1940s. Yet the quality of the job still depends on the ability (and patience) of the person who reads and interprets the label, mixes the pesticide, calibrates the sprayer, and operates it.

A 1979 survey by Rider, Dickey et al. showed that about 85 percent of the applicators in Nebraska had a calibration or mixing error in excess of five percent, and over 30 percent had both a calibration and mixing error. Calibration errors were involved in over 75 percent of the pesticide applications and were identified as the major problem. Only 22 percent, or less than one out of every four applicators, had sufficient calibration accuracy to apply the tank mix within five percent of their intended or estimated application rate. However, over 50 percent were within 20 percent of their desired rate. Moreover, 41 percent were underapplying by an average of 25 percent, and approximately 37 percent of the applicators were overapplying by an average of 29 percent. The Nebraska survey indicated that one-third of the corn crop received a 25 percent overapplication of pesticides. If the data were applied to only one state, Illinois, we could realize an annual savings of $16 million by eliminating the overapplication of pesticides to corn (assuming average pesticide costs of $16.00 per acre).

We often do not utilize application equipment to its maximum efficiency, partly because we fail to realize the importance of precise application, and partly because we do not have a clear understanding of the principles involved in applying pesticides. Even though pesticide application equipment is often the least expensive piece of machinery on the farm, proper nozzle selection, calibration, operation, and maintenance can pay big dividends.

Application Rate

Only three variables affect the amount of spray solution applied per acre: (1) the nozzle flow rate, (2) the ground speed of the sprayer, and (3) the effective sprayed width per nozzle. To calibrate and operate a sprayer properly, every applicator must know how each of these variables affects sprayer output.

Nozzle Flow Rate

The flow rate through a nozzle varies with the size of the tip and the nozzle pressure. Increasing the orifice diameter of the nozzle tip or increasing the pressure will increase the flow rate. Nozzle flow rate varies in proportion to the square root of the pressure. Doubling the pressure will not double the flow rate. To double the flow rate, you must increase the pressure four times. For example, to double the flow rate of a nozzle from 0.28 gallons per minute at 20 pounds per square inch (psi) to 0.56 gallons per minute, you must increase the pressure to 80 psi.

Ground Speed

The spray application rate varies inversely with the ground speed. Doubling the ground speed of the sprayer reduces the gallons of spray applied per acre by one-half. For example, a sprayer applying 20 gallons per acre at 3 miles per hour would apply 10 gallons per acre if the speed were increased to 6 miles per hour and the nozzle flow remained constant.

Sprayed Width per Nozzle

The effective width sprayed per nozzle (usually equivalent to the nozzle spacing) also affects the spray application rate. Doubling the effective sprayed width per nozzle decreases the gallons per acre applied by one-half. For example, if you are applying 40 gallons per acre with flat-fan nozzles on 20-inch boom spacings and you change to flooding nozzles with the same flow rate but use 40-inch spacings, the application rate decreases from 40 gallons per acre to 20 gallons per acre.

Selecting Nozzle Tips and Calibrating Sprayers

There are many methods for selecting nozzle tips and calibrating sprayers, but they all involve the use of the three variables described above. Any technique for calibration that provides accurate and uniform application is acceptable. No single method is best for everyone.

The calibration method we stress has three distinct advantages. First, it allows you to pre-select the number of gallons to apply per acre and to complete most of the calibration before going to the field. Second, it provides a simple means for frequently adjusting the calibration to compensate for changes because of nozzle wear. Third, it can be used for broadcast, band, directed, and row-crop spraying. This method requires a knowledge of nozzle types and sizes and of the recommended operating pressure ranges for each type of nozzle used.

The key to accurate calibration and subsequent proper application is to select the correct type and size of nozzle tip for each application. The nozzle determines the amount of spray applied to a particular area, the uniformity of the applied spray, the coverage obtained on the sprayed surfaces, and the amount of drift. Drift can be minimized by selecting nozzles that give the largest drop size while providing adequate coverage at the intended application rate and pressure.

Nozzle Type Selection

Although nozzles have been developed for many uses, only a few types are recommended for applying herbicides for weed control. First, let us look at several types of nozzles and their characteristics and uses, and then we will summarize their specific uses. The specific nozzle types are illustrated in Figure 1.

Regular flat-fan nozzles are used for most broadcast spraying of herbicides and for certain insecticides when excellent foliar penetration and coverage are not required. These nozzles produce a tapered-edge, flat-fan spray pattern and are available in several selected spray-fan angles, although 80-degree spray angle tips are most commonly used. The nozzles are often placed on 20-inch centers. Boom heights above the sprayed surface or canopy are given on the next page for various spray angles and should give good coverage.

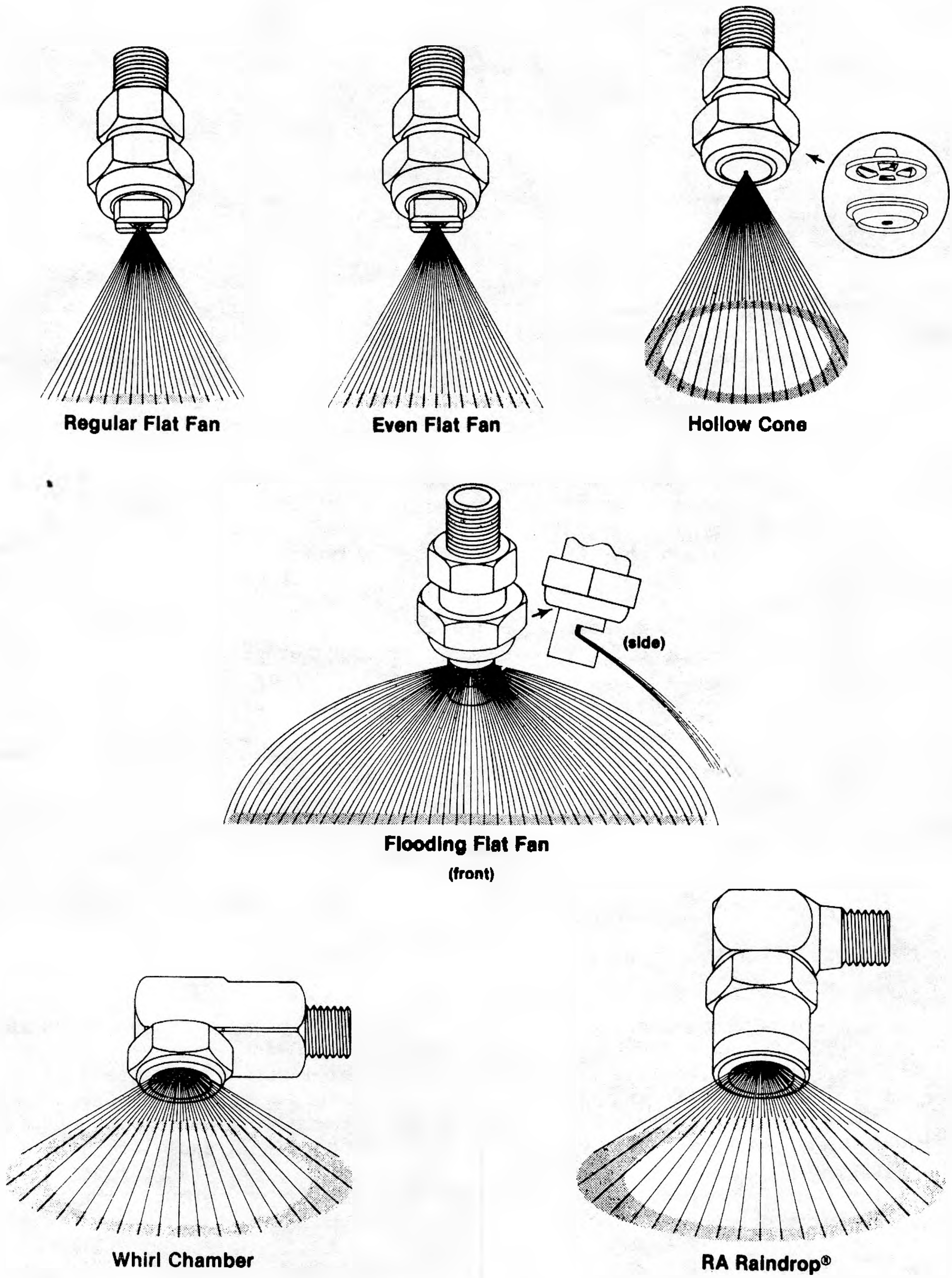


Figure 1. Nozzle types and patterns.

Spray angle (degrees)	Boom height for 20-inch spacing (inches)
65	21-23
73	20-22
80	17-19
110	10-12

When applying herbicides that do not require good coverage, keep the operating pressure between 15 and 30 psi. At these pressures, flat-fan nozzles produce medium-to-coarse drops that are not as susceptible to drift as the finer drops produced at pressures of 40 psi and higher. Regular flat-fan nozzles operated at 40 to 60 psi are recommended for some foliar-applied herbicides that need good coverage and canopy penetration. These higher pressures will generate fine drops for maximum coverage of the plant surfaces.

The LP or "low-pressure" flat-fan nozzle is available from the Spraying Systems Company. This nozzle develops a normal fan angle and distribution pattern at spray pressures from 10 to 20 psi. Operating this nozzle at a lower pressure results in larger drops and less drift than operating the regular flat-fan nozzles at pressures of 15 to 30 psi.

Even flat-fan nozzles apply uniform coverage across the entire width of the spray pattern. They should be used for banding preemergence herbicides over the crop row and should be operated between 15 and 30 psi. Band width is determined by adjusting nozzle height. The band widths for various nozzle heights are shown below.

	Nozzle height	
Band width (inches)	80-degree series (inches)	95-degree series (inches)
8	5	4
10	6	5
12	7	6
14	8	7

Flooding flat-fan nozzles produce a wide-angle, flat-fan pattern and are used for applying herbicides and mixtures of herbicides and liquid fertilizers. The nozzle spacing for applying herbicides should be 60 inches or less. These nozzles are most effective in reducing drift when they are operated within a pressure range of 8 to 25 psi. Pressure changes affect the width of the spray pattern more with the flooding flat-fan nozzle than with the regular flat-fan nozzle. In addition, the distribution pattern is usually not as uniform with the flooding flat-fan tip as with the regular flat-fan tip. However, the flooding flat-fan nozzles have a circular orifice and do not clog as easily as regular flat-fan types.

Hollow-cone nozzles (disc and core type) are used primarily when good plant coverage and foliage penetration are essential (such as for some foliar herbicides) and when drift is not a major concern. At pressures of 40 to 80 psi, hollow-cone nozzles produce small drops that penetrate plant canopies and cover the undersides of leaves more effectively than many other nozzles. If penetration is not required, the pressure should be limited to approximately 40 psi. The most commonly used hollow-cone nozzle is the two-piece, disc-core, hollow-cone spray tip. The core gives the fluid a swirling motion before it is metered through the orifice disc, resulting in a circular, hollow-cone spray pattern.

Whirl-chamber hollow-cone nozzles have a whirl chamber above a conical outlet. These nozzles produce a hollow-cone pattern with fan angles up to 130 degrees and are used primarily on herbicide incorporation kits. The recommended pressure range is 5 to 20 psi. Flow rates are controlled by the orifice size at the entrance to the whirl chamber and by the nozzle outlet. As a result, these holes are fairly large and do not clog easily.

Raindrop® hollow-cone nozzles have been designed by the Delavan Corporation for good drift control. They produce large drops in a hollow-cone pattern at pressures of 20 to 60 psi. The RD Raindrop nozzle consists of a conventional disc-core, hollow-cone nozzle to which a Raindrop cap has been added. The RA Raindrop nozzle (a whirl-chamber nozzle with the Raindrop cap) is used for preemergence herbicides, and the RD Raindrop nozzle is used for foliar spraying of herbicides that do not require thorough coverage.

Nozzle Type Selection for Applying Herbicides

Soil-Applied Herbicides

Separate boom application. We recommend the flooding and RA Raindrop nozzles for soil-applied herbicides. Clogging problems are minimized, and the nozzle height can be kept low even with wider nozzle spacings. Drop sizes will be sufficiently large so that gusty winds will not disrupt the pattern as much or cause as much drift.

Tool-mounted application. The flooding, whirlchamber, and RA Raindrop nozzles are recommended because space on most tools is limited and the mounting height needs to be kept low. Where fore and aft space is extremely limited, the flooding type is best. All three types need to be tilted 15 to 30 degrees to improve the distribution.

Band application. The even flat-fan nozzle mounted at the proper height will give uniform weed control across the entire band. If height is limited, nozzle tilt can also be used to obtain the proper band width.

Foliar-Applied Herbicides

For systemic or translocated herbicides that do not require thorough coverage, the flooding flat-fan, regular flat-fan, LP flat-fan, and Raindrop nozzles are recommended choices. If spray drift needs to be avoided, the regular flat-fan nozzles should not be used and the other three types should be operated at the low end of their recommended operating pressure range.

For those herbicides that require thorough coverage, we would recommend either the regular flat-fan or hollow cone nozzles operated at 40 psi and above. The flooding type nozzle can be used at 40 to 50 psi but needs to be mounted at an angle so that the spray is directed downward. The flooding nozzle may give somewhat less canopy penetration than the flat-fan and hollow cone nozzles.

Nozzle Size Selection for Applying Herbicides

The size of the nozzle tip needed will depend upon the application rate, ground speed, and effective sprayed width per nozzle that you plan to use. Some manufacturers advertise "gallons-per-acre" nozzles, but this rating is useful only for standard conditions (usually 30 psi, 4 miles per hour, and 20-inch spacings). The gallons-per-acre rating is useless if any one of your conditions varies from the standard. A more exact method for choosing the correct nozzle tip is to determine the gallons per minute required for your conditions, then to select nozzles that, when operated within the recommended pressure range, provide the required flow rate. The gallons per minute may be calculated by the following formula:

$$GPM = \frac{GPA \times MPH \times W}{5{,}940}$$

where: *GPM = gallons per minute of output required from each nozzle*
GPA = desired application rate in gallons per acre
MPH = measured ground speed in miles per hour
W = effective sprayed width per nozzle in inches

For broadcast spraying, W = nozzle spacing on the boom.
For band spraying, W = band width.
For row crop or directed spraying,

$$W = \frac{\text{number of nozzles per row or band}}{\text{row width or band width}}$$

Select a nozzle tip that will give the recommended flow rate when the nozzle is operated within the recommended pressure range. Nozzle catalogs are available free of charge from equipment dealers or nozzle manufacturers. These catalogs have tables listing the flow rate versus pressure for the various types and sizes of nozzles.

If, for example, you want to broadcast a herbicide at 15 GPA at a speed of 7 MPH, using flooding nozzles spaced 40 inches apart on the boom, you would determine the required flow rate for each nozzle in the following manner:

$$GPM = \frac{15 \times 7 \times 40}{5{,}940} = \frac{4{,}200}{5{,}940} = 0.71$$

The flooding nozzle that you select should have a flow rate of 0.71 GPM when operated within the recommended pressure range of 8 to 25 psi. Since the Spraying Systems TK5 and Delavan D5 nozzles have a rated output of 0.71 GPM at 20 psi, either of these nozzles could be purchased for this application.

Sprayer Calibration

Once the proper tips have been selected and installed, the actual sprayer calibration can be completed quickly and easily. It is difficult to measure fractions of a gallon accurately, so it is more convenient to convert the required nozzle flow rate to ounces per minute:

$$OPM = GPM \times 128$$

where 128 ounces = number of ounces in one gallon

From the previous example, the required nozzle flow rate was 0.71 GPM. Therefore:

$$OPM = 0.71 \times 128 = 91$$

Collect the output from one nozzle in a container marked in ounces. Adjust the pressure until the ounces per minute collected is the same as that required, making sure that the pressure remains within the acceptable range. If the pressure required is too high or too low, you have made a mistake, so check your calculations step by step. Check all the other nozzles to determine if their outputs fall within five percent of the desired rate. Replace any tips that do not. Operate the sprayer in the field at the ground speed that you used in your calculations and at the pressure you determined. Lay out a known distance and make sure your ground speed is correct. You will then be spraying at the desired application rate.

Check the nozzle flow rate every few days or when changing the pesticides being applied. Adjust the pressure to compensate for small changes in nozzle output resulting from nozzle wear or variations in other spraying components. Replace the nozzle tip and recalibrate when the output at the original pressure has changed 10 percent or more from that of a new nozzle or when the pattern has become uneven. New nozzles do not lessen the need to calibrate because nozzles "wear in" and will increase their flow rate most rapidly during the first few hours of use. With this procedure, application rates can be checked quickly and easily.

Field Operation

You can have the proper tank mix, the right nozzle type and size for your application, and the correct pressure and ground speed and still do a poor job of spraying. Even though the correct total amount of herbicide mixture per acre is applied, it may be applied nonuniformly across the boom or along the line of travel. What are some of the factors involved in applying these expensive herbicides correctly?

Distribution Patterns

When band spraying, one relies on the selection of an even spray nozzle to provide a uniform distribution of herbicide across the band. In broadcast spraying, however, the choice of nozzle type, the nozzle spacing, the nozzle height, and nozzle mounting position (vertical versus tilted) affect the distribution. The fan angle, operating pressure, ground speed, and boom bounce also influence the uniformity of application.

For each nozzle type there is a proper spray overlap that results in the best distribution across the swath. Spray overlap is the amount of the pattern on the ground or on the canopy that gets covered by more than one nozzle, as shown in Figure 2. The upper drawing shows 50 percent of the pattern getting coverage from one nozzle and 50 percent getting coverage from two nozzles for a 50 percent overlap. The lower drawing shows 100 percent of the pattern getting coverage from two nozzles for 100 percent overlap (frequently called double coverage). If a recommendation is given for 110 percent overlap then 10 percent of the pattern is to get coverage from three nozzles and the other 90 percent of the pattern gets double coverage.

The amount of overlap desired for nozzles operated on a boom depends primarily on the distribution across the individual pattern, and this varies with the nozzle type. In looking at the distribution patterns of different nozzles, it is best to consider several possible distributions as shown in Figure 3.

The rectangular distribution shown in Figure 3(a) is desired from a band nozzle. Distribution is uniform across the entire pattern so that weed control is obtained at the edge as well as in the middle. The amount of herbicide applied in the middle of the band is no more than that at the edge so that the germinating crop is less likely to be damaged. Nozzles producing this pattern should not be used on a boom since no overlap is required. If overlap occurs, the herbicide rate is doubled, and if the boom height decreases, then untreated strips occur.

A triangular pattern as shown in Figure 3(b) requires 100 percent overlap to obtain uniform coverage. Such distributions are rare from agricultural spray nozzles. The trapezoidal pattern shown in Figure 3(c) is somewhat similar to that obtained from regular flat-fan nozzles. The length of the flat top of the trapezoidal pattern in relation to the rate of decrease in application on both sides of the individual pattern determines the amount of overlap needed. For most flat-fan nozzles, the amount of overlap required is 30 to 50 percent.

The oval pattern shown in Figure 3(d) is obtained from full cone pattern nozzles (nozzles where the hollow center obtained with hollow cone nozzles is also filled with spray) and some flat-fan nozzles. The amount of overlap required is between 20 to 30 percent, an amount that is less than that required for most trapezoidal patterns.

The double humpback pattern of Figure 3(e) is typical of that obtained from hollow cone nozzles spraying straight down. The hollow cone core and disc type nozzles with spray angles of 60 to 80 degrees have a pattern with a fairly narrow valley between the two peaks. The amount in the center is not much less than the peaks; therefore, overlapping only 20 to 40 percent may be better than a double overlap. One must make sure, however, that the overlap is not enough to impose the peak from one nozzle on the peak of the adjacent nozzle.

Hollow cone nozzles of the wide angle whirlchamber type produce a double humpback pattern with the peaks fairly far apart as shown in Figure 3(f). As a result, the overlap should be 110 to 115 percent to impose the humps from one nozzle inside the hump of the nozzle on each side, as shown in Figure 3(g). The best distribution is obtained when 10 to 20 percent of the pattern receives spray from three nozzles.

Flooding flat-fan nozzles also tend to have the double humpback pattern if mounted so the spray is almost straight down. They also will provide much better distribution if overlapped 110 to 115 percent, as shown in Figure 3(g).

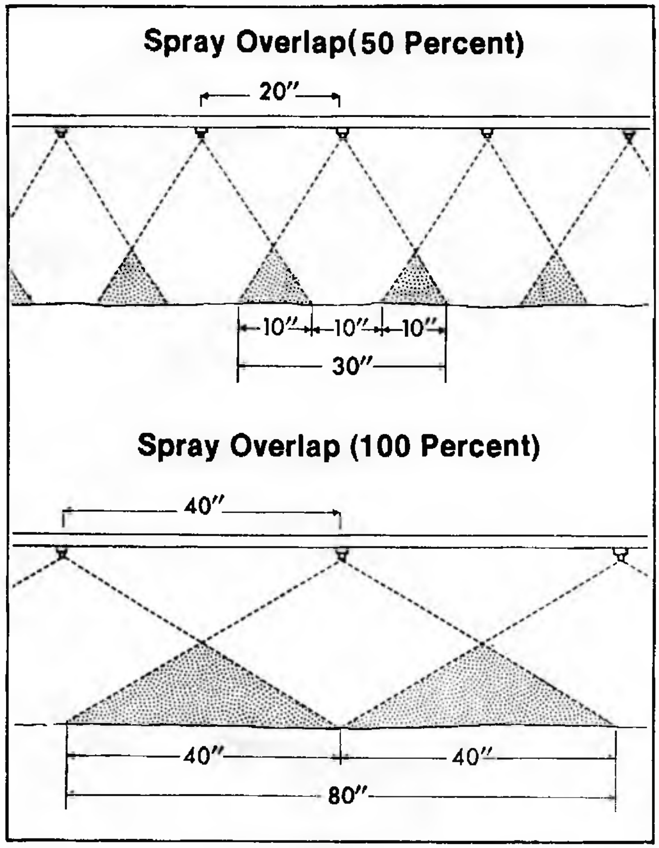


Figure 2. Illustration of 50 percent and 100 percent overlaps.

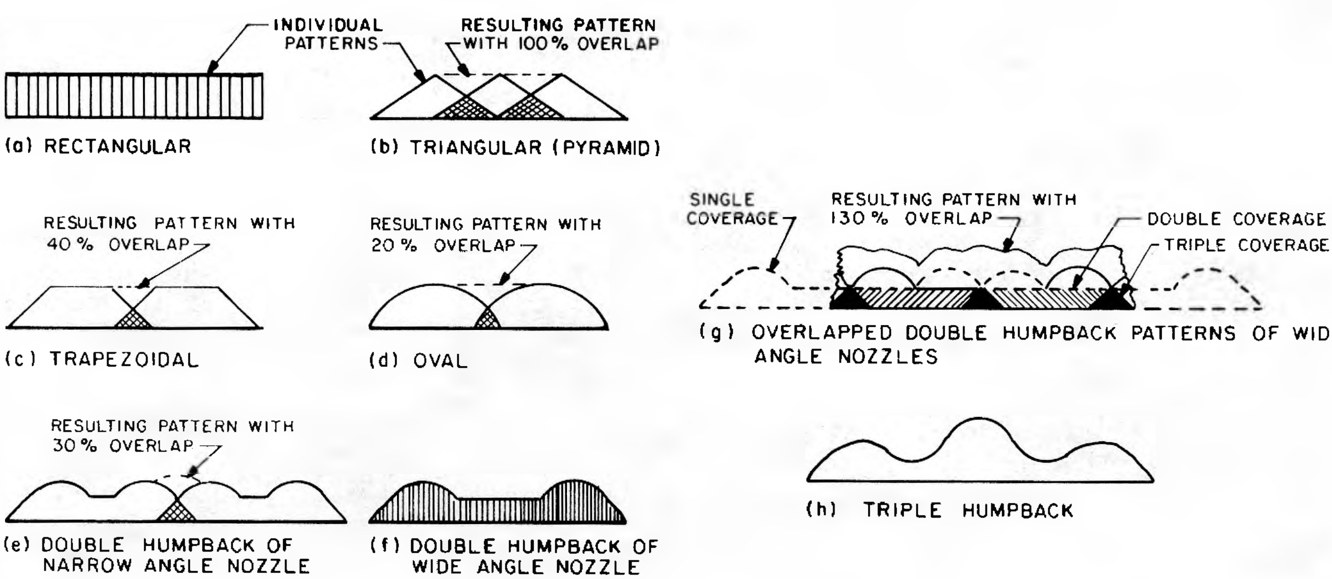


Figure 3. Possible distribution patterns.

Patterns of both types of hollow cone nozzles and of the flooding flat-fan nozzles will also be improved by tilting the nozzle mounting so that the spray trajectory is 20 to 45 degrees from the vertical. Tilting also permits the desired overlap without using unreasonable nozzle mounting heights. The Delavan Raindrop nozzles are hollow cone nozzles that also benefit from 110 to 115 percent overlap and tilt angles of 20 to 45 degrees.

The triple humpback pattern shown in Figure 3(h) is obtained from badly worn flat-fan and flooding flat-fan nozzles. Nozzles worn this much need to be replaced since their patterns can not be properly overlapped.

The Spraying Systems 8002 regular flat-fan nozzle produced the pattern shown in Figure 4. An overlap of 50 percent was required at 20 psi to obtain the very low coefficient variation of 2.3 percent. Note that the flat top of the individual pattern is quite narrow. At 40 psi an overlap of 40 percent resulted in the most uniform pattern and coefficient of variation of 3.7 percent. (We believe that coefficient variations of less than 10 percent are satisfactory.) The lower percent overlap required at the higher pressure is due to the flat top of the individual pattern being wider at 40 psi than at 20 psi.

The Spraying Systems flooding flat-fan TK-40 nozzle produced the pattern shown in Figure 5. An overlap of approximately 125 percent was required to obtain the optimum pattern. Operating pressure was 15 psi, nozzle height was 38 inches, and the nozzle was tilted upwards at 30 degrees. With this nozzle the spray then travels downward at a 50-degree angle from the vertical. This pattern can be described as fitting between the double and triple humpback patterns described earlier. The flooding nozzle patterns are consistently best at 110 to 130 percent overlap.

The Delavan RA-4 Raindrop nozzle in Figure 6 has a hollow cone pattern producing the classic double peak pattern. At 50 psi and spraying vertically downward from a 22 inch height, the best overlap was shown to be 121 percent with a spacing of 28 inches. Narrower spacings of 24 inches and wider spacings of 32 inches or more resulted in much greater variations in distribution amounts as the graph shows. One could obtain satisfactory distributions at wider spacings by raising the boom and/or by tilting the nozzles but making sure to maintain overlaps of 110 to 130 percent.

Other Factors to Consider

To obtain proper distribution patterns in the field, one must remember that (1) boom height above the spray surface must be different in different fields and (2) individual nozzle patterns are narrower when the sprayer is moving than when the sprayer is stationary. Therefore, you can make preliminary adjustments based on the nozzle type and position, but *always* make your final adjustment for proper overlap under field conditions or as close to field conditions as possible.

Among other causes of serious variations in the distribution across the swath are variations in boom height due to bouncing, a tire low on air, improper boom mounting, and bent booms. The boom should be kept parallel to the spray surface at all times. If boom height varies, it is better to be a little too high than a little too low. Also try to keep the boom ends from swinging fore and aft as coverage is very light as the boom swings forward and very heavy as it swings back. Remember also that spraying while making sharp turns must be avoided. The inner end of the boom may spray three or four times the desired rate and the outer end may apply one-half the rate. It is best to spray the field ends separately so the sprayer can be

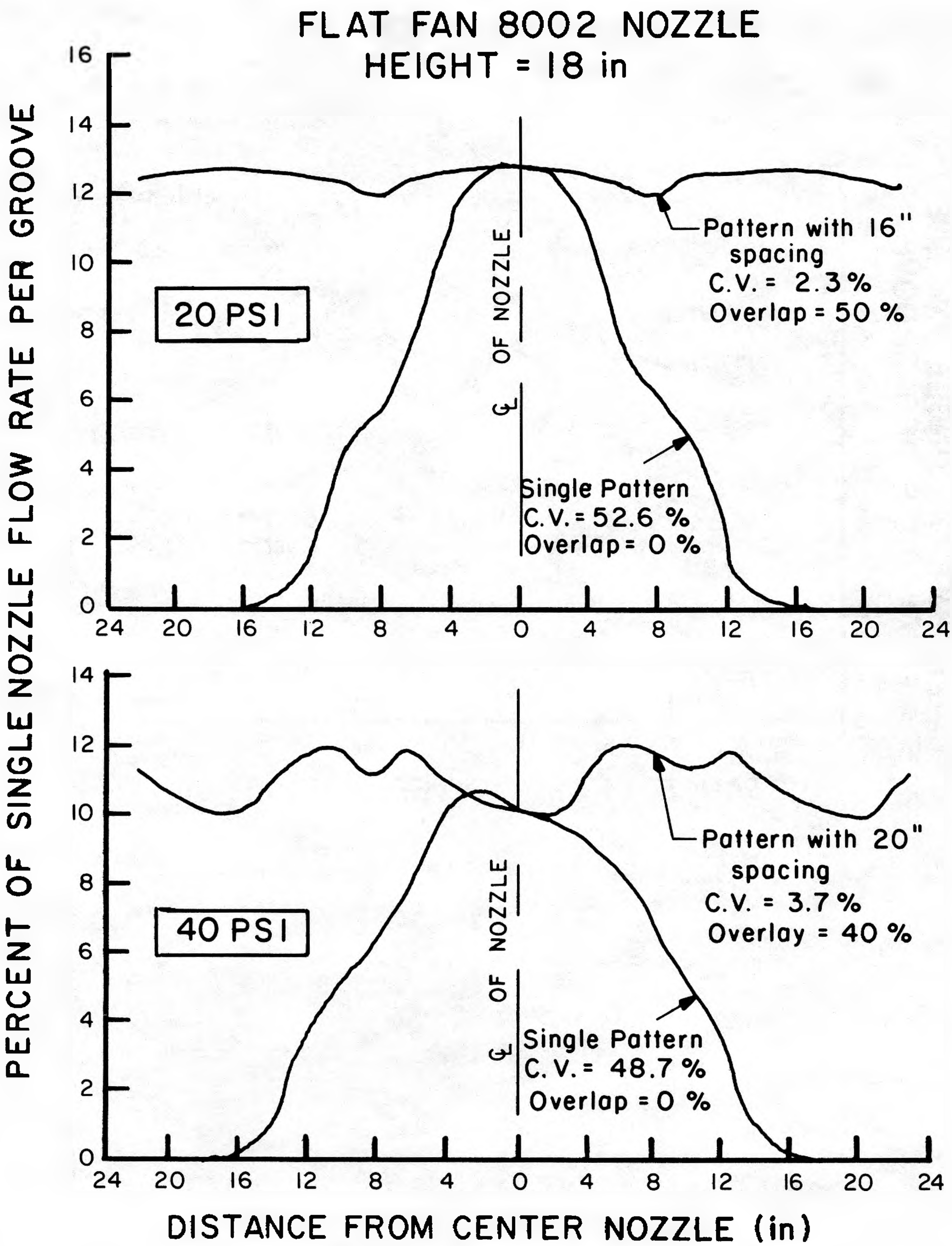


Figure 4. Optimum distribution patterns for Spraying Systems 8002 flat-fan nozzle at 20 and 40 psi.

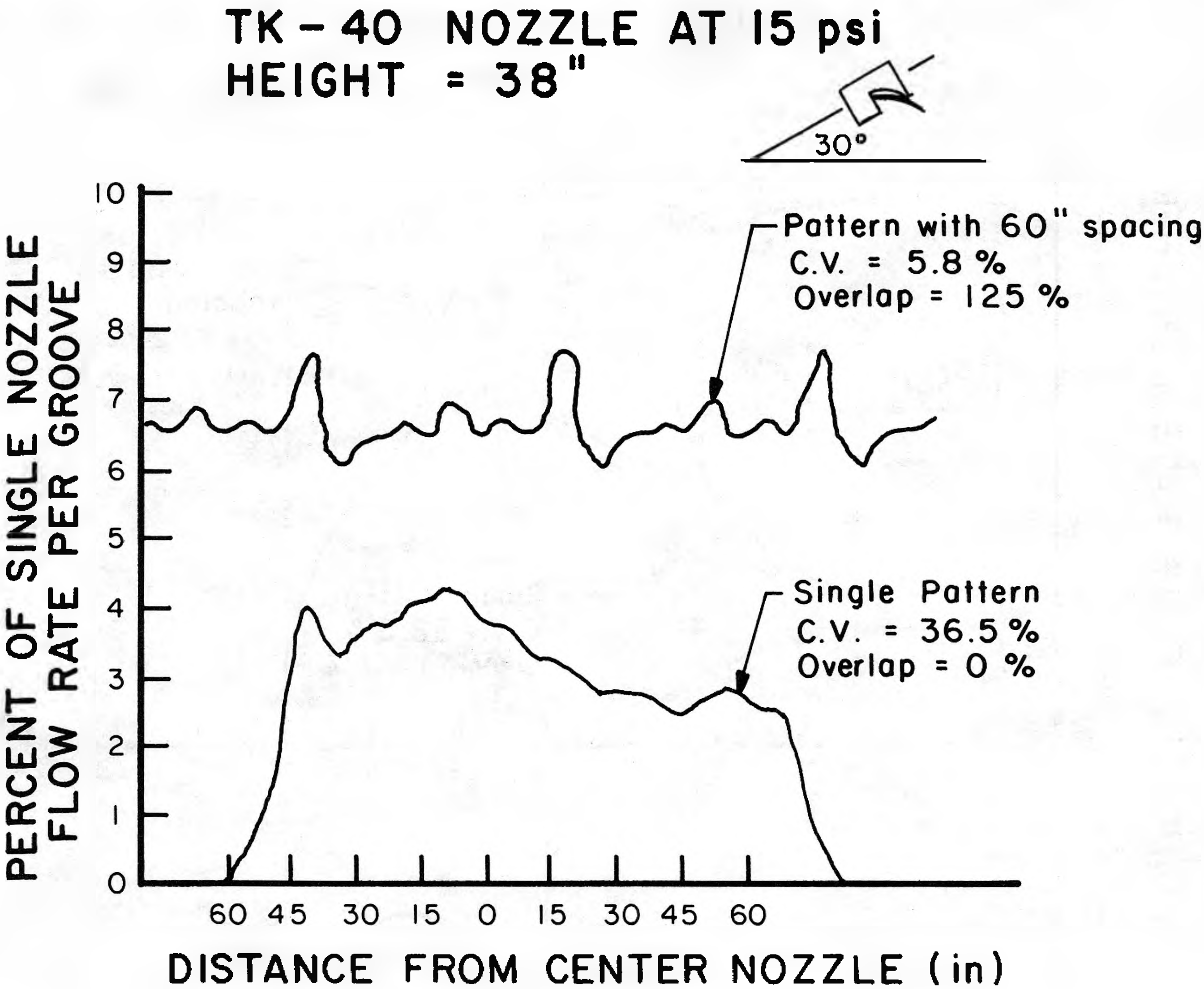


Figure 5. Optimum distribution pattern for Spraying Systems TK-40 flooding flat-fan nozzle at 150 psi, 30° tilt.

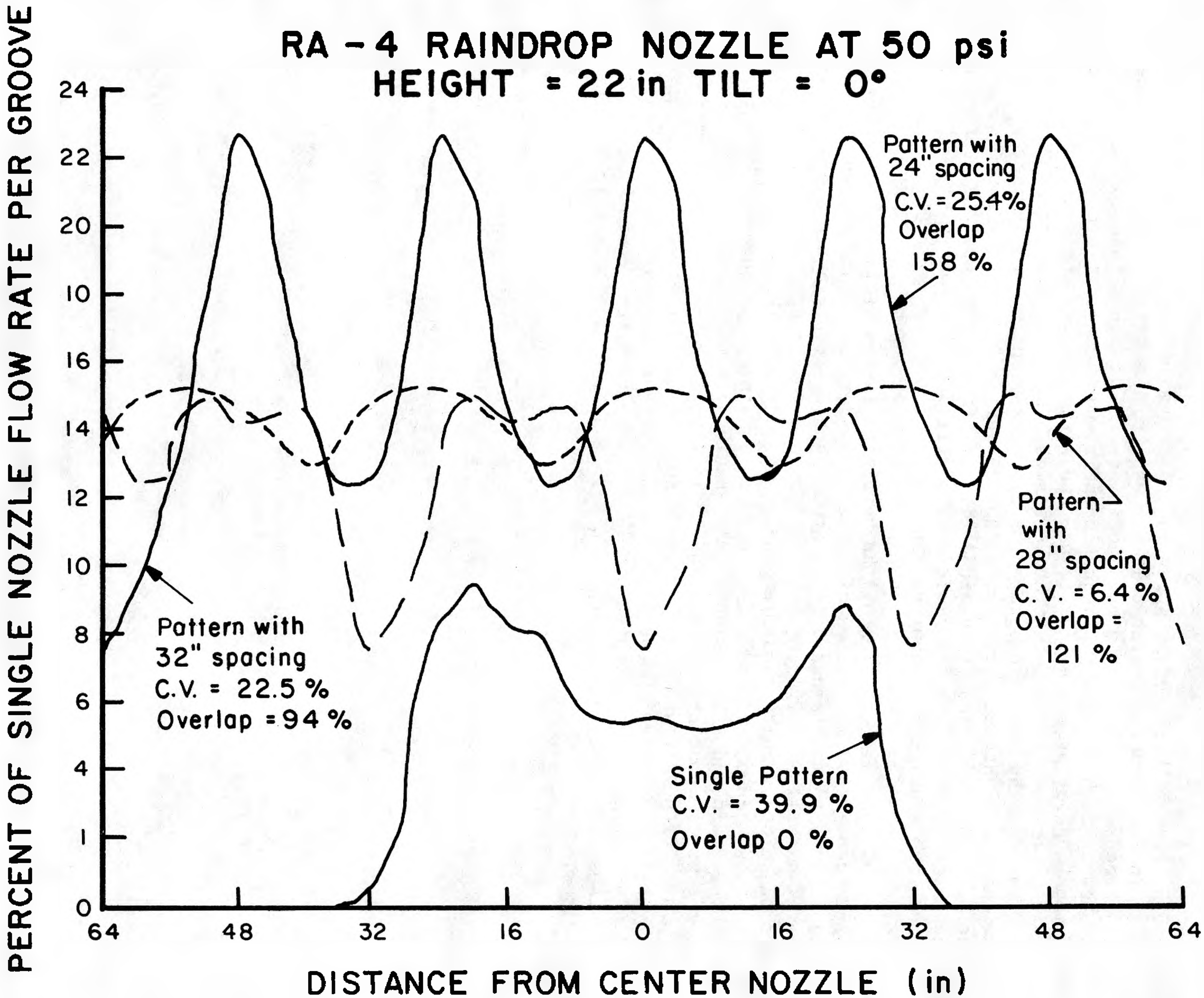


Figure 6. Distribution patterns for Delavan RA-4 Raindrop hollow cone nozzle at three nozzle spacings.

shut off before making turns. Use of nozzle check valves will help to assure rapid cutoff of the spray (and rapid turn on also).

Do not use nozzles with different spray angles or outputs on the same boom. Watch for changes in individual patterns that may be a result of clogged line strainers or nozzle screens or of worn or damaged orifices. Do not hesitate to change nozzles that are showing light or heavy streaks in their individual patterns. A practical means of checking for proper height to use above the sprayed surface is to spray at what you think is the proper height above a smooth surface (such as a road, lane, or lot) at the desired nozzle pressure. Start slowly and gradually increase speed. You will find the light and heavy spots show up well. Study their source, raise or lower the boom as needed and try again until satisfied. Then operate at that height above the sprayed surface in the field, which will usually mean raising the boom to account for tire sinkage or canopy height.

Other causes of poor distribution of the herbicide in the field are: (1) failure to make and keep a good suspension of wettable powders or liquid flowables in the tank, (2) failure to maintain a uniform ground speed, resulting in different application rates as well as different spray angles and nozzle outputs, (3) adjusting pressures based on a faulty pressure gauge (two gauges in the system are desirable to let you know when one is bad), (4) failure to maintain uniform swath widths (after a turn at the field end, the inside nozzle should have moved laterally a distance equal to the nozzle spacing, no more and no less), (5) failure to adjust pressures to compensate for nozzle wear or to replace nozzles after their flow rates have increased over 10 percent at the desired pressure, (6) foaming of the spray mixture, especially as the tank nears empty, and (7) failure to make frequent checks of amount applied versus acreage covered (spray monitors can help with this checking but they can err also).

Calibration of Granular Applicators

Loren E. Bode and Stephen L. Pearson

Granular pesticides for weed, insect, disease, or nematode control must be applied accurately for effective and safe pest control. They may be broadcast on soil or turf, or applied in bands over rows of field crops either before or after planting. Granules have limited use for most foliar application because they will not stick to the foliage, although they are valuable for corn borer control when the granules are placed in the corn whorl. Formulations of granules contain a certain percent of pesticide active ingredient (a.i.). The remainder is an inert material used to make enough bulk so that the granules can be handled safely and applied accurately. The major advantage of using granules is that they are ready for direct application with no mixing. Granular applicators are relatively inexpensive and simple to use, but require extreme care in calibration for precise application.

Types of Granular Applicators Available

Available granular units range from hand-operated applicators for lawns, to band applicators for row crops, to powered applicators covering wide swaths. These units distribute granules in several ways including pneumatic (air carriers), whirling discs (seeders, fertilizer spreaders), multiple hole gravity or force feed spreaders (lawn spreaders, broadcast drills), soil injectors (furrow treatments) and ram air (agricultural aircraft).

Metering of the granules is generally accomplished by gravity-flow or positive-feed. Gravity-flow applicators are the most common and consist of a hopper with a metering orifice in the bottom. Granules flow through the orifice by gravitational force. There should be an agitator above the orifice, rotating in the bottom of the hopper to keep the granules from bridging and blocking the orifice. This type of applicator is very sensitive to travel speed. Generally, the application rate decreases as the travel speed increases. Rate of application is determined by an adjustable gate that controls the effective size of the orifice.

Positive metering applicators have an auger or a notched rotor which rotates in the bottom of the hopper to deliver a constant amount of granules to the discharge openings. The number, exposed width, and depth of notches on the rotor vary according to the type of applicator and desired application rate. Application rate can also be varied by changing the rotor speed. Positive metering applicators are more complicated and costly than the gravity-flow type. However, positive-metering applicators are less sensitive to changes in travel speed. Increasing travel speed generally results in a minimal decrease in application rate.

Use Calibration Charts Only as Guideline

The owner's manual should help determine the initial setting needed to apply the recommended rate. Pesticide labels may also suggest certain settings at which the granules should be used. However, it is not sufficient to use these charts for a final setting because several factors can cause a variation in the application rate.

The application rate of granules applied depends on the size of the metering opening, speed of the agitator or rotor, travel speed, roughness of the field, and flowability of the granules. Granules flow at different rates, depending on size, density, type of granule, temperature, and humidity. Many granules look somewhat alike at first glance, but there is a wide variation in the size and density of the particles, and in the nature of the inert carrier for the pesticides. For these reasons, a different applicator setting may be necessary for each pesticide applied. A different setting may even be required for the same pesticide formulated by two different manufacturers or in two batches by the same manufacturer.

Ground speed is the most significant factor affecting the application rate besides the orifice setting. Calibration must be done at the same speed used in the field, and speed must be kept constant during application. Even though gravity-flow applicators use a rotating agitator whose speed varies with ground speed, the flow of granules through the orifice is not proportional to the speed. It is not uncommon to find a 50-percent variation in the application rate when changing ground speed only a few miles per hour.

Temperature and humidity affect the moisture content of the granules, resulting in flow changes from day to day. Surface roughness can affect the application rate when changing from one field to another. It is therefore important to calibrate frequently to maintain the proper application rate.

Individual units on row applicators should be calibrated independently. Even when all the applicators are set the same, tests have shown that large differences in application rate may occur among the different row units. Only by regularly checking calibration on all units can the correct application rate be maintained. The calibration charts furnished with the application unit should be used only as a guideline for the initial setting of the applicator during calibration.

Determining the Amount of Pesticide to Apply

Calibration begins by determining the correct rate of granules to apply. Recommendations vary according to the amount and type of pesticide being used. Rates are usually expressed as pounds per broadcast area (acre of 1,000 square feet) or as ounces per 1,000 feet of row.

Because the same pesticides may be available in different concentrations of granules, written recommendations are sometimes given as pounds of active ingredient to apply per acre (lb. a.i./A). For these recommendations you must first convert the lb. a.i./A to pounds of product per acre for the granules you have purchased. To convert, read the label to determine the percent of active ingredient in the granules. Then convert the lb. a.i./A to pounds of product per acre (lb./A) by the following equation:

$$\text{lb. product/A} = \text{lb. a.i./A} \times \frac{100\%}{\%\text{ a.i. in product}} \qquad \text{(Equation 1)}$$

Example: A recommendation calls for 3 lbs. a.i./A. You have purchased a 20% granular formulation. Using Equation 1, how much material should you apply per acre?

$$\text{lb. product/A} = 3 \text{ lbs. a.i./A} \times \frac{100\%}{20\%} = \frac{300}{20} = 15$$

You should apply 15 pounds of product per acre.

Table 1 was developed from the above formula and can be used to determine the total quantity of granules needed per acre (lb./A) if the recommended lb. a.i./A and granule concentration are included in the table.

Table 1. Quantity of Granules Needed per Acre to Give a Desired Rate When Using Formulations Having Various Concentrations of Active Ingredient

Desired application rate (lb. a.i./A)	Active ingredient in granules (%) 4	5	10	15	20	25
	Pounds of granular product to apply per acre					
1.0	25	20	10	7	5	4
2.0	50	40	20	13	10	8
3.0	75	60	30	20	15	12
4.0	100	80	40	27	20	16
5.0	125	100	50	33	25	20
6.0	150	120	60	40	30	24
7.0	175	140	70	47	35	28
8.0	200	160	80	53	40	32
9.0	225	180	90	60	45	36
10.0	250	200	100	67	50	40
12.5	313	250	125	83	63	50
15.0	375	300	150	100	75	60
17.5	438	350	175	117	88	70
20.0	500	400	200	133	100	80
25.0	625	500	250	167	125	100
30.0	750	600	300	200	150	120
35.0	875	700	350	233	175	140
40.0	1000	800	400	267	200	160
45.0	1125	900	450	300	225	180
50.0	1250	1000	500	333	250	200

Broadcast or Band

For all herbicides (banded and broadcast) and broadcast insecticides and nematicides, apply the recommended pounds per broadcast acre. Remember that when banding you still apply the same rate of granules in the band as you do when broadcasting. The only difference with banding is that you do not treat the entire area, resulting in less total product being applied to an actual field. That is, you must drive over more than one acre in the field to actually treat one acre of banded area.

$$\text{Treated acres} = \text{total acres} \times \frac{\text{inch band}}{\text{inch row}} \qquad \text{(Equation 2)}$$

Example: You want to apply a granular herbicide at 20 lbs. of product/A in a 14-inch band over 30-inch soybean rows. How many pounds should be purchased to treat 200 acres of soybeans?

$$\text{Treated acres} = 200 \text{ acres} \times \frac{\text{14-inch band}}{\text{30-inch row}} = 93.3$$

93.3 acres x 20 lb./A = 1867 lb. of granules needed

In-the-Row

Applications of insecticides and nematicides (banded or furrow treatments) are based on ounces per 1,000 linear feet of row, rather than pounds per broadcast acre. These materials require a constant concentration of pesticide per linear foot of row, whether they are banded or placed in the furrow. Once you have calibrated a granular row applicator to apply the recommended ounces/1,000 feet of row, it will apply the correct rate of granules for any row spacing used. The same rate will be applied down the row with the total amount applied per field acre changing in proportion to row spacing.

When purchasing granules for in-the-row applications, row spacing will determine the total amount of granules needed per field. In addition to ounces per 1,000 feet of row, manufacturers generally list the recommended pounds per acre for a standard row width such as 40 inches, 36 inches, 22 inches, etc. For row spacings other than the standard width given on the label, the amount of granules needed per acre will change proportionally in order to maintain a uniform concentration per foot or row. This is because the total feet of row per acre increases as row spaceing decreases.

Example: If a recommendation calls for 15 lbs./A for 40-inch rows and you are planting 20-inch rows, you need to apply 30 lbs./A to maintain the same concentration of pesticide in the row. One acre contains 13,068 feet of 40-inch rows and at 15 lbs./A each 1,000 feet of row would receive 18.3 ounces of granules. The same acre planted in 20-inch rows would have 26,136 feet of row. To maintain the same 18.3 ounces of granules per 1,000 feet of row, it would require 30 pounds of granules applied to each acre rather than the 15 lbs./A applied to the 40-inch rows.

Table 2 shows the feet of row per acre for several row spacings. You can calculate the total feet of row per acre for any row spacing by dividing 43,560 sq. ft./A by the row spacing in feet (Equation 3).

Table 2. Total Feet of Row per Acre for Various Row Spacings

Row spacing (in.)	Feet of row per acre
7	74,674
15	34,848
20	26,136
22	23,760
30	17,424
32	16,335
34	15,374
36	14,520
38	13,756
40	13,068
42	12,446
50	10,454
60	8,712

$$\text{ft. of row/acre} = \frac{43{,}560 \text{ sq. ft./A}}{\text{row spacing in ft.}} \qquad \text{(Equation 3)}$$

Example: You have planted a field in 30-inch rows (30 inches = 2.5 feet). Using Equation 3, how many feet of row are in each acre?

$$\text{ft. of row/acre} = \frac{43{,}560 \text{ sq. ft./A}}{2.5 \text{ row spacing (ft).}} = 17{,}424$$

If a recommendation is given only as oz./1,000 feet of row, it can be converted to lb./A for your row spacing with the following formula:

$$\text{lb./A} = \frac{\text{oz./1,000 ft. of row} \times 2{,}722}{\text{1,000 ft. of row} \times \text{row spacing in ft.}} \qquad \text{(Equation 4)}$$

where: 2,722 = a constant arrived at by dividing the number of square feet in 1 acre (43,560) by the number of ounces in 1 pound (16)

Example: A soil insecticide recommendation calls for 6 oz./1,000 ft. of row. If you are planting in 22 inch rows (22 inches = 1.83 ft.), how many lb./A of insecticide should be applied?

$$\text{lb./A} = \frac{\text{6 oz./1,000 ft.} \times 2{,}722}{\text{1,000 ft. of row} \times \text{1.83 row spacing (ft.)}}$$

$$= \frac{16{,}332}{1{,}833} = 8.9$$

Calibration of the Granular Applicator

Most calibration techniques are based on determining the amount of granules dispensed when treating a known area. The procedure used here is to adjust the applicator setting until you collect the required amount of granules while traveling a measured distance, or treating a measured area.

Step 1.

Determine the number of ounces required for application over a known distance.

Broadcast or band applications. Calculate the number of ounces required to be distributed over a measured course.

$$\text{oz. required} = \frac{\text{lb./A} \times \text{area treated (sq. ft.)}}{2{,}722} \qquad \text{(Equation 5)}$$

Area treated is the area actually covered with granules, and is the length of measured course in feet times the width of spread in feet. For broadcast applications, measure the effective swath width, and for band applications, measure the band width.

Example 1: A recommendation is to apply 10 lbs./A of herbicide granules in a 14-inch band (14 inches = 1.2 feet) over each row. A 1,000 foot measured course is to be used. How many ounces should be collected when the applicator is operated over the 1,000 foot measured course?

$$\text{area treated} = 1{,}000 \text{ ft.} \times 1.2 \text{ ft.} = 1{,}200 \text{ sq. ft.}$$

$$\text{ounces required} = \frac{20 \text{ lb./A} \times 1{,}200 \text{ sq. ft.}}{2{,}722}$$

$$= \frac{24{,}000}{2{,}722} = 8.8$$

Example 2: A broadcast application of an insecticide granule is to be applied to turf at 3 lbs./A. The effective swath width is 60 inches (5 feet). A 500-foot distance is used for calibration. How many ounces should be collected?

$$\text{area treated} = 500 \text{ ft.} \times 5 \text{ ft.} = 2{,}500 \text{ sq. ft.}$$

$$\text{ounces required} = \frac{3 \text{ lb./A} \times 2{,}500 \text{ sq. ft.}}{2{,}722}$$

$$= \frac{7{,}500}{2{,}722} = 2.7$$

In-the-row applications. The number of ounces per 1,000 feet of row is usually listed on the label. If a recommendation is given only as lb./A for a standard row spacing, you can convert it to oz./1,000 feet of row with the following formula:

oz./1,000 ft. of row =

$$\frac{\text{lb./A} \times \text{std. row spacing (ft.)} \times 1{,}000 \text{ ft. of row}}{2{,}722} \qquad \text{(Equation 6)}$$

Example: A soil insecticide recommendation calls for 10 lbs./A when applied in 30-inch row (30 inches = 2.5 ft.). Using Equation 6, how many oz./1,000 ft. of row are required for proper calibration?

oz./1,000 ft. of row =

$$\frac{10 \text{ lb./A} \times 2.5 \text{ std. row spacing (ft)} \times 1{,}000 \text{ ft. of row}}{2{,}722}$$

$$= \frac{25{,}000}{2{,}722} = 9.2$$

Step 2

Adjust the initial setting on each applicator according to the equipment manufacturer's recommendation.

Step 3

Attach a container (plastic bag or plastic jar) over the outlet of the applicator and collect the granules while operating over the measured distance at the speed you plan to apply. Make the calibration run in the field to be treated so that speed and traction conditions will be constant.

Step 4

Weigh the collected granules minus the weight of the container. Since the amount collected may only be a few ounces or grams, the granules should be weighed on a postal scale, baby scale, or food scale. Volume measurements may be inaccurate because of nonuniform settling or segregation of granules. If the amount collected is not equal to the ounces required (Step 1), adjust the gate setting then repeat the calibration until you collect the required amount. Do this for all units on a row type applicator.

Checking the Application Rate

After you have calibrated the applicator to apply the proper amount of granules, make periodic field checks to verify that the application rate does not change from one day to the next, or from one field to another. There are several ways to do this.

One simple method is to place a strip of masking tape vertically on the inside of the application hopper. Then fill the hopper in increments of 1 or 2 pounds. After each increment is added, shake the hopper to settle the material and mark the tape at the level of the chemical. Throughout the season, the application rate can be verified by simply reading the level of chemical before and after treating a known number of acres.

$$\text{lb./A} = \frac{\text{pounds used}}{\text{acres treated}} \qquad \text{(Equation 7)}$$

Example: When doing a field check you find 12 lbs. of granules were applied to 5 acres. Using Equation 7, what is the application rate?

$$\text{lb./A} = \frac{\text{12 pounds used}}{\text{5 acres treated}} = 2.4$$

Determining the number of acres treated is important for an accurate field check of the application rate. The acres treated for one unit can be calculated if the distance traveled and the width of spread are measured.

acres treated =

$$\frac{\text{distance traveled (ft.) x width (ft.)}}{\text{43,560 sq. ft./A}} \qquad \text{(Equation 8)}$$

Width = Swath width, band width, or row spacing in feet

For row crops the number of acres treated can be estimated from the number of rows and the length of the field.

no. of rows/acre =

$$\frac{\text{43,560 sq. ft./A}}{\text{row spacing (ft.) x length of field (ft.)}} \qquad \text{(Equation 9)}$$

Table 3 lists the number of rows per acre for various row spacings and length of fields.

For in-the-row or broadcast treatments, you can use the following formula to determine the lb./A being applied:

$$\text{lb./A} = \frac{\text{no. of rows/acre x lb. used}}{\text{rows treated}} \qquad \text{(Equation 10)}$$

Example: After planting 26 rows of corn spaced 30 inches apart, (30 inches = 2.5 ft.) an applicator used 6 lbs. of soil insecticide. The field is 1/4 mile long (1,320 ft.). How many lb./A are being applied.

no. of rows/acre =

$$\frac{43{,}560 \text{ sq. ft./A}}{2.5 \text{ row spacing (ft.) x } 1{,}320 \text{ length of field (ft.)}}$$

$$= \frac{43{,}560}{3{,}300} = 13.2$$

$$\text{lb./A} = \frac{13.2 \text{ rows/acre x 6 lb. used}}{26 \text{ rows treated}}$$

$$= \frac{79.2}{26} = 3.0$$

The granular applicator is applying the soil insecticide at a rate of 3 pounds per acre.

When applying granules in a band, you are treating only a part of each acre in the field. Therefore, to determine the actual number of acres treated you must increase the values in Table 3 (number of rows required to treat one acre) by the ratio of row spacing to band width.

no. of rows/treated acre =

$$\text{no. of rows/acre x } \frac{\text{row spacing (in.)}}{\text{band width (in.)}} \qquad \text{(Equation 11)}$$

For banding, the number of rows required to treat one acre will be greater than the number for broadcasting, or applying in-the-row treatments.

Example: A granular herbicide is being applied in a 12-inch band over 30-inch (2.5 feet) corn rows. The field is 1/4 mile long (1,320 ft.). While planting 26 rows, a granular applicator unit used 6 pounds of granules, how many lb./A are being applied?

No. of rows/ treated acre =

$$13.2 \text{ rows/acre x } \frac{30 \text{ row spacing (in.)}}{12 \text{ band width (in.)}} = \frac{396}{12} = 33$$

$$\text{lb./A} = \frac{\text{33 rows/acre x 6 lb. used}}{\text{26 rows treated}} = \frac{198}{26} = 7.6$$

The granular applicator is applying herbicide in the band at a broadcast rate of 7.6 pounds per acre. If this is not the amount recommended on the label, the unit should be recalibrated.

Table 3. Number of Rows Per Acre for Various Row Spacings and Lengths of Fields

	Length of field (ft.)							
Row spacing (in.)	330	660	990	1320	1650	1980	2310	2640
	Number of rows per acre							
7	226	113	75	57	45	38	32	28
15	106	53	35	26	21	17.6	15.1	13.2
20	79	40	26	19.8	15.8	13.2	11.3	9.9
22	72	36	24	18.0	14.4	12.0	10.3	9.0
30	53	26	17.6	13.2	10.6	8.8	7.5	6.6
34	47	23	15.5	11.6	9.3	7.8	6.7	5.8
36	44	22	14.7	11.0	8.8	7.3	6.3	5.5
38	42	21	13.9	10.4	8.3	6.9	6.0	5.2
40	40	20	13.2	9.9	7.9	6.6	5.7	5.0
42	38	18.8	12.6	9.4	7.5	6.3	5.4	4.7
50	32	15.8	10.6	7.9	6.3	5.3	4.5	4.0
60	26	13.2	8.8	6.6	5.3	4.4	3.8	3.3

Other Factors to Be Considered

For band application, the width of the band is determined by the design of the spreader and also by the height of the spreader above the surface. The height should be adjusted until the desired band width is obtained. On some models the spreader height is difficult to adjust, resulting in limited control of the band width.

On some applicators a flexible hose carries the granules from the hopper to the spreaders. The hose should have a uniform slope to provide uniform flow of the granules from the metering orifice to the spreader. If the hose is too long to provide a smooth slope, cut off small amounts of the hose until uniform flow is maintained. The swath width must be accurately determined for applicators having spinner type distributors. The distribution pattern from these units is generally less at the outside edges and some overlapping on adjacent passes is required to obtain uniform spreading. The effective swath width is the actual distance between successive passes to obtain a uniform distribution and not the total distance from the extreme outer edges of the pattern.

THE CALIBRATION OF HIGH-CAPACITY FLOTATION SPRAYERS

High-capacity sprayers are widely used for application of agricultural chemicals. Initially developed for application of fertilizers, the flotation concept quickly expanded to the application of pesticides and fertilizer-pesticide combinations. Flotation means faster application, heavier loads, less soil compaction, and additional days for application because of being able to work in wet fields. Maintaining precise application with high-capacity sprayers is more than applying the correct amount of chemical on a field. It also requires that the chemical is applied uniformly over the entire field. Applications with partially clogged or worn nozzles do occur. Double overlapping and skips from improper swath marking are not uncommon. Procedures for checking the quality of application are simple if clearly understood by the operator.

I. WHAT TYPE OF SPRAY NOZZLE SHOULD I USE?

Proper selection and operation of spray nozzles is the most important part of pesticide application. The nozzle determines the amount of spray applied to a given area; the uniformity of the applied spray; the coverage obtained on the sprayed surfaces; and the amount of drift that occurs. A conscientious applicator minimizes the drift problem by selecting nozzles that give the largest droplet size while still providing adequate coverage at the intended application rate and pressure. Although nozzles have been developed for practically every kind of spray application, only a few types are commonly used on high-capacity flotation sprayers.

Flooding Flat-Fan (Fig. 1)

High application rates and speeds used by custom applicators require the use of high capacity nozzles. Flooding nozzles are by far the most common and, when used properly, they are well suited for most applications. Large orifices minimize clogging problems and the wide angle spray pattern allows wide swaths to be sprayed with only a few nozzles. Uniformity of application with flooding nozzles depends on nozzle pressure, nozzle height, nozzle spacing, and nozzle orientation.

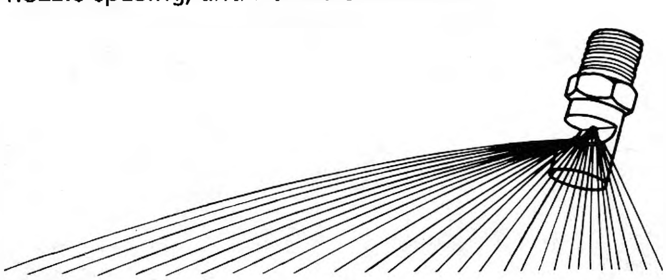


Fig. 1. Flooding Flat-Fan Nozzle.

Pressure affects application in several ways. It influences droplet size, nozzle flow rate, spray angle, and pattern uniformity. At low pressures flooding nozzles produce large spray drops; at high pressures these nozzles actually produce smaller drops than do regular flat-fan nozzles at an equivalent flow rate. For drift control, flooding nozzles should be operated below 25 PSI of pressure.

The spray distribution patterns of flooding nozzles vary greatly with changes in pressure (Fig. 2). At low pressures, flooding nozzles have a fairly uniform pattern across the swath, but at high pressure the pattern becomes heavy in the center with a tapered edge effect. Therefore, to obtain an

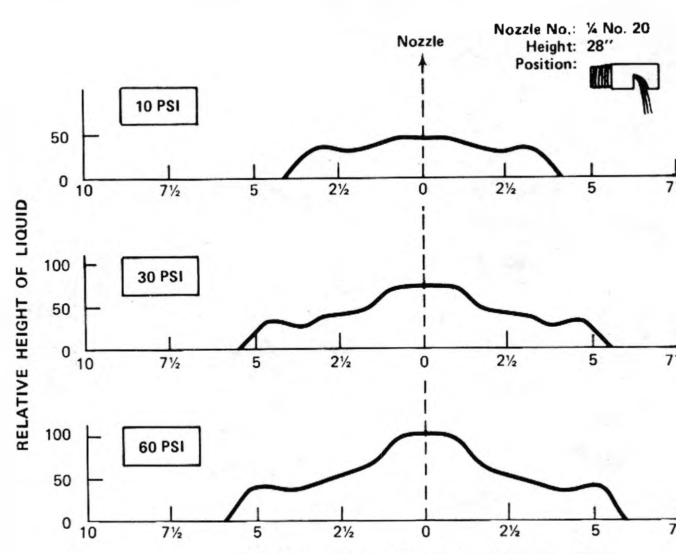


Fig. 2. Changes in spray distribution patterns of flooding nozzles due to pressure differences.

acceptable distribution pattern, the pressure range for flooding nozzles should be limited from 8 to 25 PSI.

The width of the spray pattern is influenced by pressure. For example, a number 30 flooding nozzle will produce 9.5 foot spray pattern when operated at 10 PSI and a height of 28 inches. As pressure increases to 30 PSI, the width increases to 13.5 feet. Pattern widths from nozzles with higher flow rates vary even more. Therefore, to obtain acceptable overlap, the pressure range should be limited from 8 to 25 PSI (Fig. 3).

#30 flooding nozzle

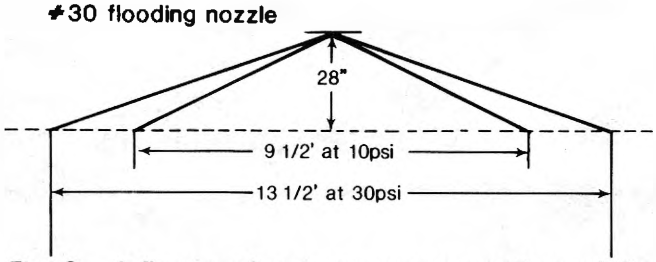


Fig. 3. Influence of pressure on spray pattern width.

Nozzle height is critical in obtaining a uniform application. For example, a number 70 flooding nozzle mounted vertically and spraying at 20 PSI will decrease its pattern width more than 6 feet when the nozzle height is reduced from 36 to 25 inches above the ground (Fig. 4). Don't forget that the nozzle pattern width is 15 to 20 percent less when traveling 12 to 16 MPH than when stopped. Once the proper nozzle height has been determined, the travel speed must be selected according to field conditions to obtain uniform application and to keep the boom from whipping back and forth or bouncing up and down. For most applications, maximum travel speeds of 12 to 16 MPH should be maintained, rather than the speeds of 18 to 22 MPH that are sometimes used.

Improper overlap is a common problem with flooding nozzles. To best compensate for pattern variability due to pressure, height, and spacing, the recommended nozzle arrangement for applying pesticides is shown in Fig. 5. With this arrangement, the nozzles are spaced on 40 to 80 inch centers and the height adjusted to obtain double coverage or 100 percent overlap. With 100 percent overlap, the individual nozzle patterns reach the center of the pattern of each adjacent nozzle and the entire surface receives spray from two nozzles. Proper overlap can be obtained by raising or lowering the boom for each pressure and nozzle size used. Boom height generally is not changed during pressure changes from automatic metering systems reacting to changes in ground speed. In such cases speed must be maintained within a range to maintain the pressure within the recommended 8 to 25 PSI range.

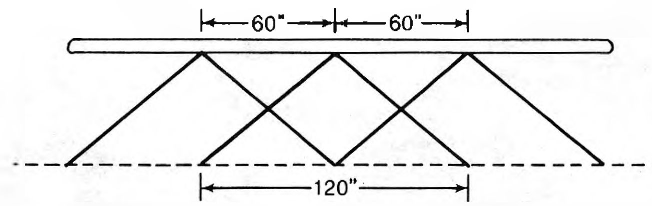


Fig. 5. 100% Overlap.

Flooding nozzles can be mounted vertically to spray back, horizontally to spray down, or at any angle between vertical and horizontal (Fig. 6). When the nozzle is mounted horizontally to spray down, there is a tendency for heavy concentrations of spray to occur at the edges of the spray pattern (Fig. 7). Tests have shown that rotating the nozzles 30 to 45 degrees from the horizontal will generally increase the pattern uniformity over a pressure range of 10 to 30 PSI. For uniform distribution over a range of pressures, nozzles should be mounted to obtain double coverage at the lowest operating pressure (Fig. 8).

Figures 9 and 10 indicate the decrease in accuracy of spray distribution when flooding nozzles are spaced on 10-foot centers. With a pressure change from 10 to 30 PSI the patterns are not suf-

#70 flooding nozzle at 20psi

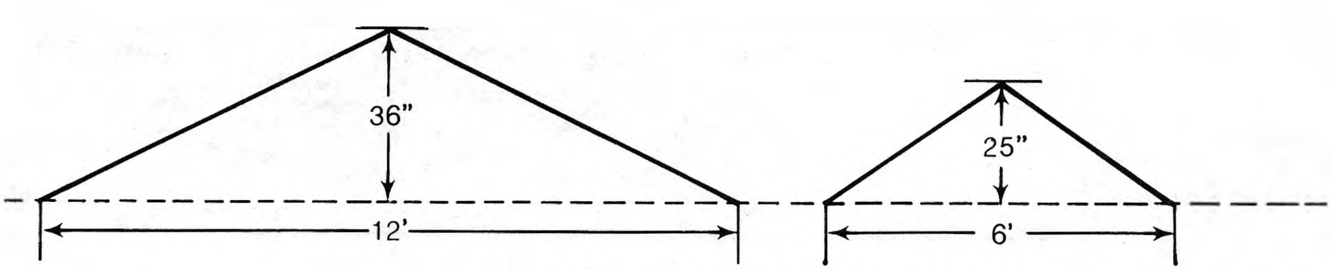


Fig. 4. Influence of height on spray pattern widths.

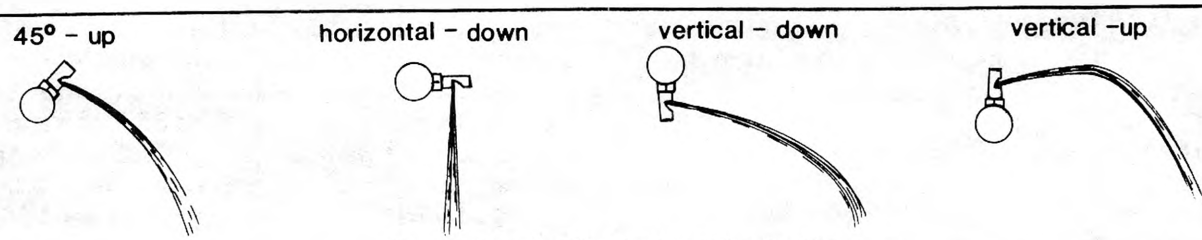


Fig. 6. Flooring Nozzle Operating Positions.

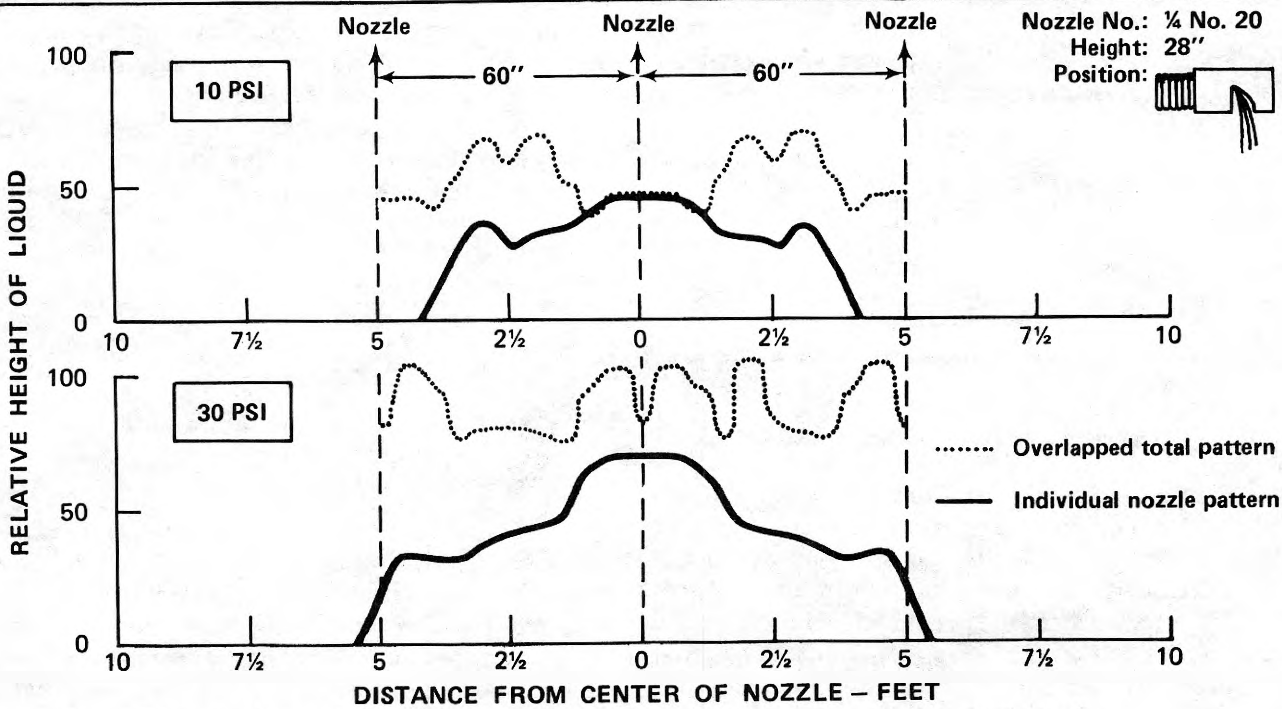


Fig. 7. Effect of Nozzle Operating Position and Pressure on Uniform Spray Distribution.

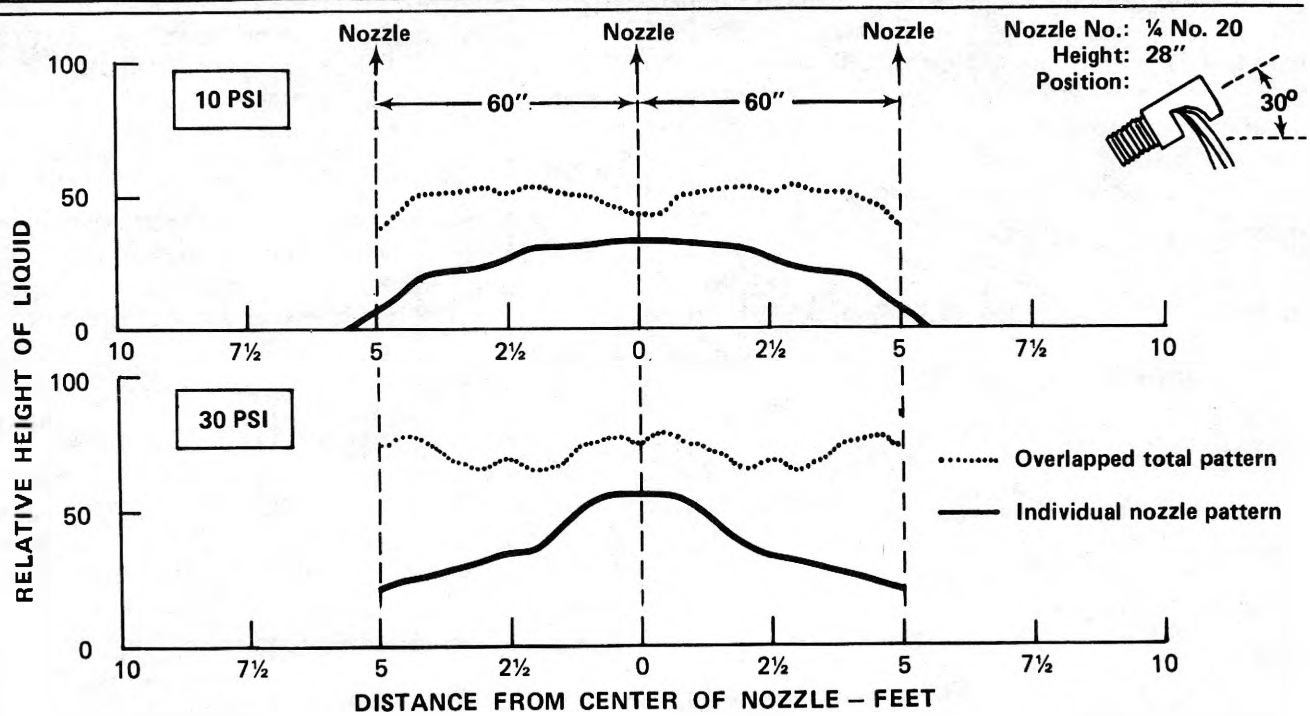


Fig. 8. Effect of Nozzle Operating Position and Pressure on Uniform Spray Distribution.

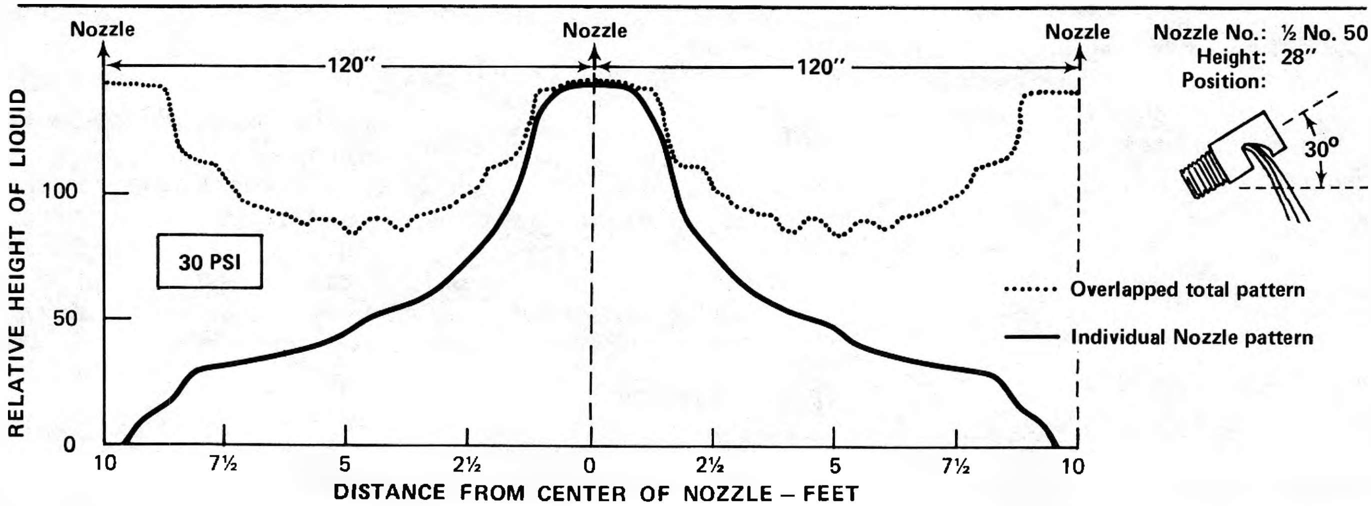


Fig. 9. When Flooding Nozzles are Spaced on 10-foot Centers the Accuracy of the Spray Distribution is Decreased.

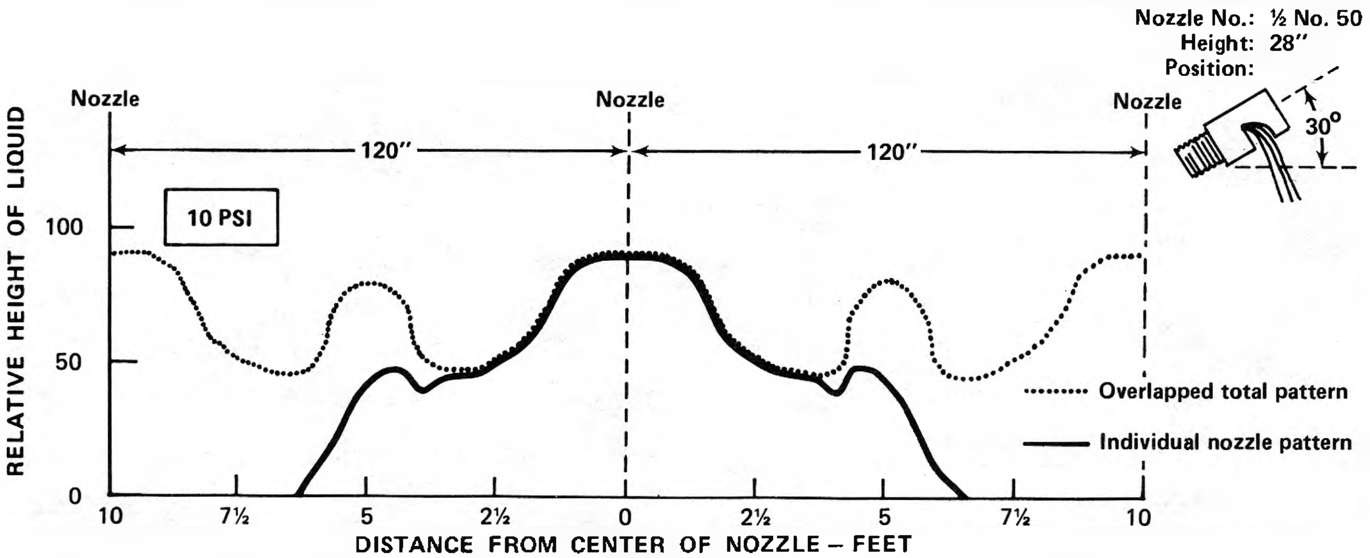


Fig. 10. When Flooding Nozzles are Spaced on 10-foot Centers the Accuracy of the Spray Distribution is Decreased.

ficiently uniform for applying pesticides. Therefore, for applying pesticides, nozzle spacing should be less than 80 inches.

Raindrop® (Fig. 11)

The RA Raindrop nozzle is recommended when spray drift is a major problem. When operated within a pressure range of 20 to 50 PSI, the nozzle delivers a wide-angle hollow cone spray pattern, and produces fewer smaller drops than the flooding nozzle. To obtain a uniform spray pattern the nozzle should be spaced no more than 60 inches apart and rotated from 30 to 45 degrees from the vertical axis. Large droplets produced for drift control reduce the coverage required for some foliar pesticides. When using this nozzle adjust to obtain double coverage or 100 percent overlap.

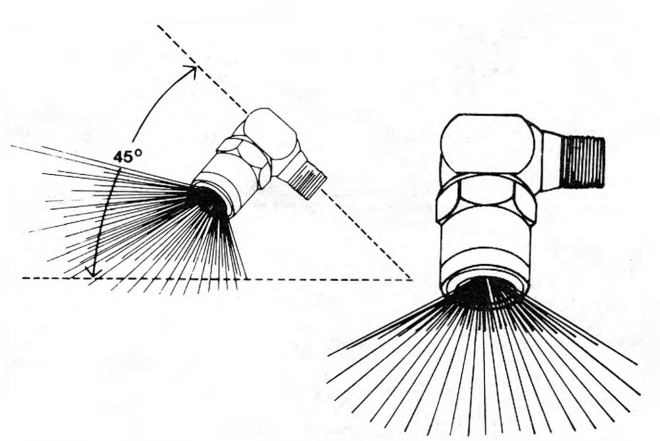


Fig. 11. RA Raindrop.

Regular Flat-Fan (Fig. 12)

Regular flat-fan nozzles are sometimes used on high-clearance and pickup sprayers and for foliar applications where better coverage is required than can be obtained from the high-capacity flooding nozzles (Table 1). Flat-fan nozzles are normally on

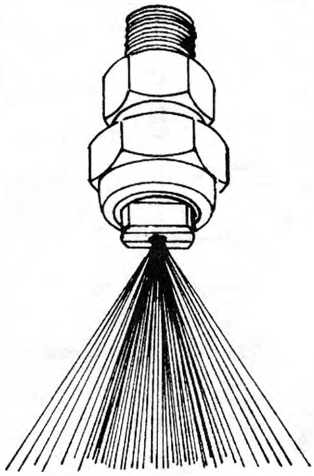


Fig. 12. Regular Flat Fan.

Table 1. Regular Flat Fan Spray Angle

Spray Angle	Nozzle Height 20" Spacing
65°	21-23
73°	20-22
80°	17-19
110°	10-12

20-inch centers with a boom height of 17 to 23 inches. Overlapping of spray patterns should be about 40 to 50 percent of the nozzle spacing to obtain uniform spray distribution (Fig. 13). For soil applications, the recommended pressure range is from 15 to 30 PSI. At pressures from 40 to 60 PSI smaller drops are produced and high pressures should only be used to apply foliar pesticides that require penetration into the canopy and maximum

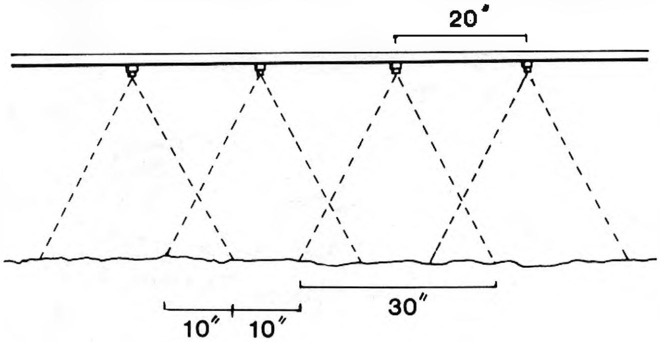


Fig. 13. 50% Overlap.

coverage. Drift potential must be a major concern at pressures above 30 PSI.

Hollow Cone (Fig. 14)

Hollow cone nozzles are used primarily when plant foliage penetration is essential for effective pest control, and when drift is not a major concern. At pressures of 40 to 80 PSI, these nozzles produce small drops that penetrate plant canopies and cover the underside of leaves more effectively than other nozzles. The most commonly used nozzle is the two piece disc-core hollow cone spray tip. The cone gives

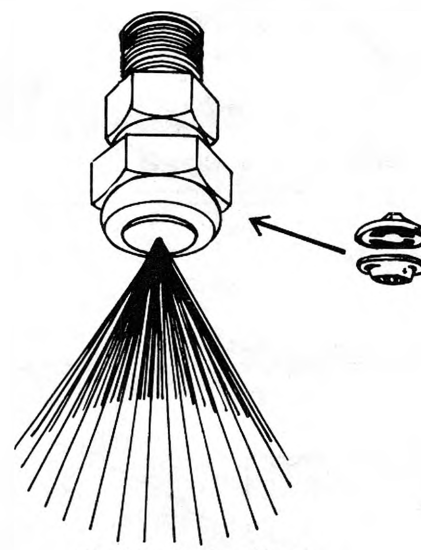


Fig. 14. Hollow Cone.

the fluid a swirling motion as it is metered through the orifice disc, resulting in a circular hollow cone spray pattern. For complete coverage of a row crop, one to five nozzles are used per row (Fig. 15).

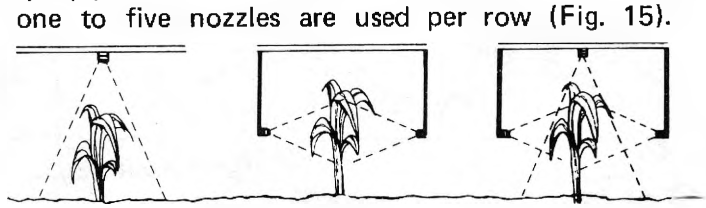


Fig. 15. Nozzle Positions of the Hollow Cone.

Nozzle Materials

Nozzle tips are available in a variety of materials including hardened stainless steel, stainless steel, nylon, and brass. Hardened stainless steel is the most wear-resistant material, but the most expensive. Stainless steel, nylon and other synthetic plastics have excellent wear resistance with either corrosive or abrasive materials. For custom application of fertilizer and pesticide to large acreages hardened stainless steel most likely is the most cost efficient nozzle material. (Fig. 16).

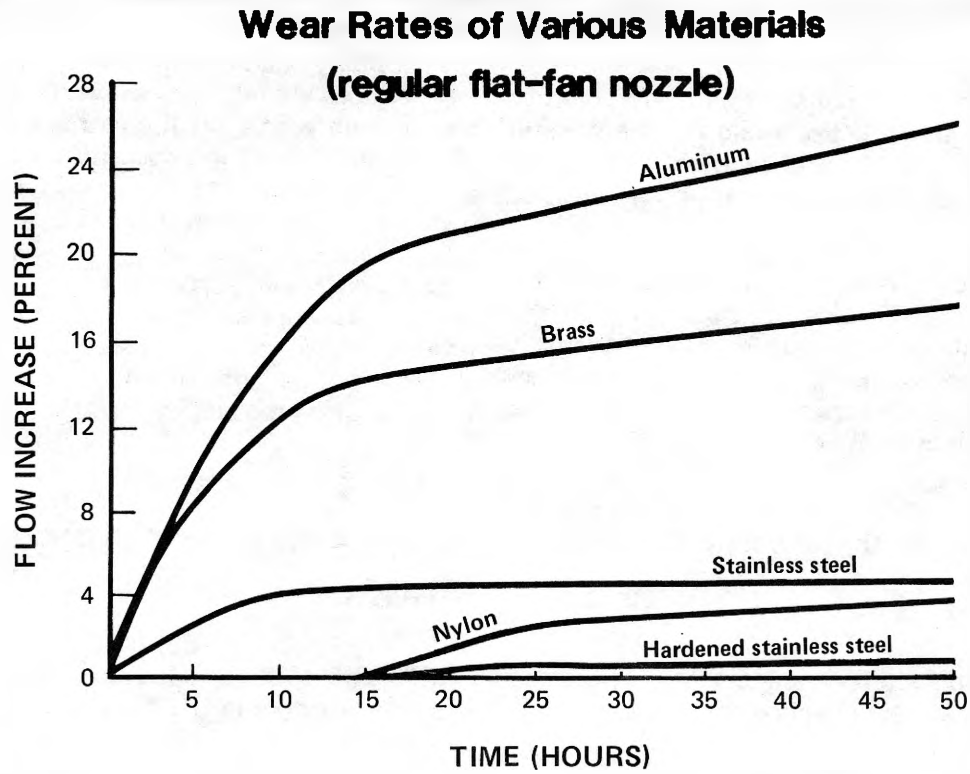


Fig. 16.

II. DOES THE TYPE OF SPRAY SOLUTION BEING USED AFFECT THE ACCURACY AND UNIFORMITY OF APPLICATION?

Several characteristics of the solutions being applied affect the accuracy and uniformity of application. Surface tension, density, and viscosity affect the flow rate and the spray distribution pattern. Surface tension is important in determining droplet size produced but its effect on flow rate and distribution is minor for the range of materials generally applied.

Density of the spray solution, especially when pesticides are applied in fertilizers, affects the flow rate through the nozzle. Density refers to the weight of a gallon of solution (lb./gal.). Water weighs 8.34 lb./gal. Oils are generally lighter than water and fertilizers are heavier than water. Flow through a nozzle decreases when switching from water to a heavier fertilizer solution or suspension. FLOW RATE VARIES INVERSELY WITH THE SQUARE ROOT OF THE FLUID DENSITY.

Tables in nozzle manufacturers' catalogs list flow rates for water in gallons per minute (GPM) at various pressures. Factors to correct the flow rate for other solutions are generally in the catalogs. For example, the flow rate for a No. 30 flooding nozzle is 4.2 GPM at 20 PSI. The conversion factor for a fertilizer having a density of 12 lb./gal. is 0.83 (Table 2). The flow rate of the fertilizer through the nozzle at 20 PSI is 4.2 GPM x 0.83 = 3.5 GPM.

Table 2. Specific gravity and flow rate conversion factors for fluids having various densities.

Weight of Solution (lb./gal.)	Specific Gravity	Conversion Factor
7.0	0.84	1.09
8.0	0.96	1.02
8.34*	1.00	1.00
9.0	1.08	0.96
10.0	1.20	0.91
11.0	1.32	0.87
12.0	1.44	0.83
14.0	1.68	0.77
16.0	1.92	0.72
18.0	2.16	0.68
20.0	2.40	0.65

*Water

Density of solutions are sometimes given as specific weight. Specific weight is the relative weight of a solution to that of water. It is determined by dividing the density of the solution by the density of water (8.34 lb./gal.). For example, the specific weight of a 12 lb./gal. fertilizer solution is 12 ÷ 8.34 or 1.44. The fertilizer solution is 1.44 times heavier than water.

An increase in viscosity results in a reduction of nozzle flow rate because of friction within the liquid, the nozzle, and its orifice. High viscosity is a major problem when applying some suspension fertilizers. Viscous suspensions flow at lower rates than rates predicted from nozzle catalogs. Tests have shown measured flow rates for a moderate viscosity suspension over 10% lower than those predicted from catalog charts. More discrepancy would occur with a more viscous suspension. If possible, diluting the mixture with a small quantity of water (usually 10 percent) lowers the viscosity for ease of handling and application. Tests show that for uniform application the viscosity of a suspension should be less than 1,000 centiposes at 70°F, which is equivalent to SAE 50W oil at 70°F. When a highly viscous solution is sprayed through flooding nozzles, a heavier concentration of material tends to occur on the edge of the spray pattern. Decreasing the viscosity by dilution reduces this tendency.

III. WHAT VARIABLES DETERMINE THE AMOUNT OF SPRAY APPLIED PER ACRE?

There are only three variables that affect the amount of spray material applied per acre:

1. Nozzle flow rate
2. Ground speed of sprayer
3. Sprayed width per nozzles

The effect of each of these variables on sprayer output must be understood in order to properly calibrate and operate your sprayer (Fig. 17).

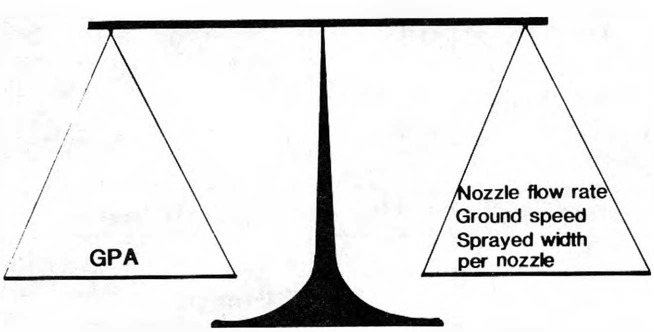


Fig. 17. The Three Variables Affecting the Amount of Spray Material Applied per Acre.

Nozzle Flow Rate

The flow rate through a nozzle varies with the size of the nozzle tip and the nozzle pressure. Installing a nozzle tip that has a larger orifice or increasing the pressure will increase the nozzle flow rate. Nozzle flow rate varies in proportion to the square root of the pressure. Therefore, DOUBLING THE PRESSURE WILL NOT DOUBLE THE FLOW RATE; TO DOUBLE THE NOZZLE FLOW RATE, PRESSURE MUST INCREASE FOUR TIMES. For example, to double the flow rate of a nozzle from 2.0 gallons per minute (GPM) at 10 PSI to 4.0 GPM, the pressure must be increased four times to 40 PSI (Table 3).

Table 3. Pressure Effects on Nozzle Flow Rates

Nozzle Type	Pressure (PSI)	Flow (GPM)
Spraying systems TK-20	10	2.0
or	20	2.8
Delavan D-20	30	3.5
	40	4.0

Pressure cannot be used to make major changes in application rate. It can be used to correct minor changes due to nozzle wear and other factors. Operating pressure must be maintained within the recommended range for each nozzle type to obtain a uniform spray pattern and minimize drift hazard (Fig. 18).

Ground Speed of the Sprayer

Spray application rate varies inversely with the travel speed. DOUBLING THE GROUND SPEED OF A SPRAYER REDUCES THE GALLONS OF SPRAY APPLIED PER ACRE (GPA) BY ONE-HALF. This assumes that nozzle pressure remains constant when ground speed is changed. For example, a sprayer applying 20 GPA at 12 MPH

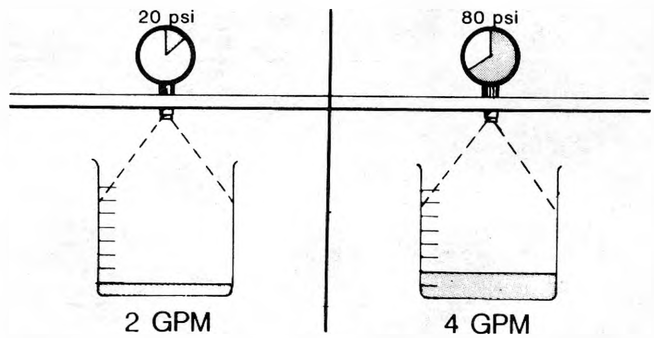


Fig. 18. In order to double the output of an orifice the pressure must be increased four times.

would apply 10 GPA if the speed was reduced to 6 MPH and the pressure remained constant (Fig. 19).

Flotation sprayers generally have some type of metering system that maintains a constant gallonage per acre when operating over a range of travel speeds. All systems now in use, such as ground-driven piston pumps, electronic feedback control systems, and various centrifugal-pump arrangements, vary nozzle pressure with change in travel speed to keep the gallons per acre constant. Therefore, all the systems will work over a wide range of travel speeds but the spray nozzle is the factor limiting the range of speeds at which precise application can be obtained.

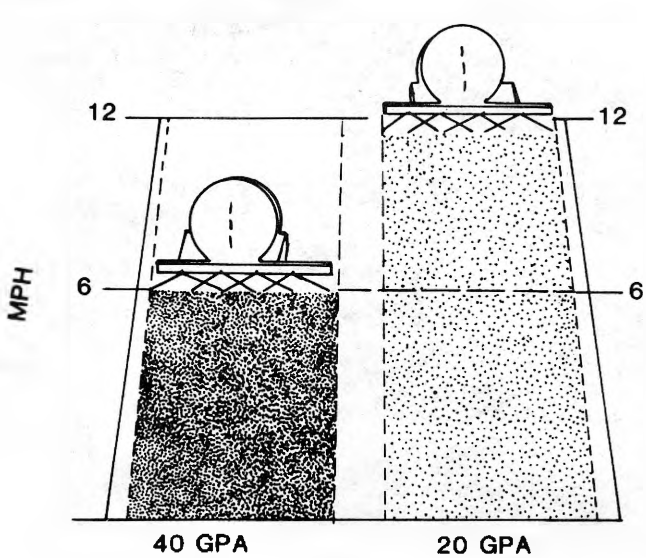


Fig. 19. If the output remains the same and the travel speed is doubled, the gallons per acre decrease by one-half.

To regulate the flow in proportion to the travel speed, the nozzle pressure must vary by the square of the speed. If an applicator is traveling at 8 MPH and is operating at a pressure of 20 PSI at the nozzle, increasing the speed to 16 MPH requires raising the pressure at the nozzle to 80 PSI. Keep in mind that a fourfold range in pressure drastically changes the droplet size, pattern width, and distribution pattern. For uniform application, constant speed should be maintained as much as possible even when using controlled metering systems (Fig. 20).

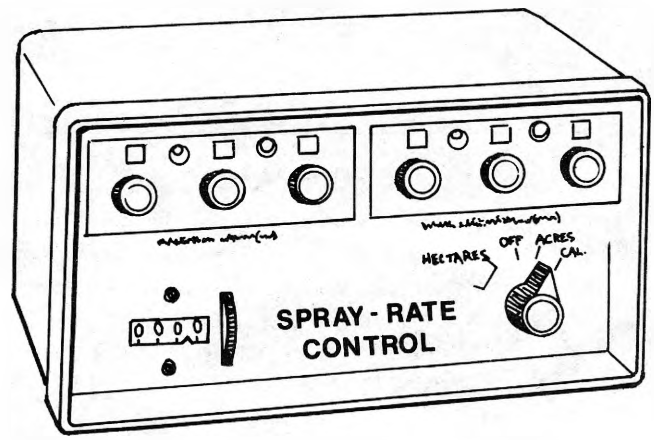


Fig. 20. Automatic Spray-Rate Control System.

Variations in speed should always be limited in order to maintain the nozzle pressure within the recommended range. For flooding nozzles this would be 10 to 25 PSI. For example, if the calibrated set point for flooding nozzles is 15 PSI, the permissible variation in speed is + 25 percent of the calibrated speed. On the other hand, if the calibrated set point is 25 PSI, speed variation is limited to + 10 percent and −40 percent. This higher pressure setting allows turning at the ends of the field at lower speeds while still obtaining a good pattern when the boom is turned back on after making the turn.

Effective Sprayed Width Per Nozzle

The effective width sprayed per nozzle also affects the spray application rate. DOUBLING THE SPRAYED WIDTH PER NOZZLE DECREASES THE GALLONS PER ACRE APPLIED BY ONE-HALF. For example, if you are applying 20 GPA with flooding nozzles on 120-inch spacings, then switch to the same size flooding nozzles on 60-inch spacings, the application rate would increase from 20 GPA to 40 GPA (Fig. 21).

The gallons of spray applied per acre (GPA) can be determined from the 3 variables listed above by using the following equation:

$$GPA = \frac{GPM \times 5940}{MPH \times W} \qquad \text{(Equation 1)}$$

where GPM = output per nozzle in gallons per minute

MPH = ground speed in miles per hour

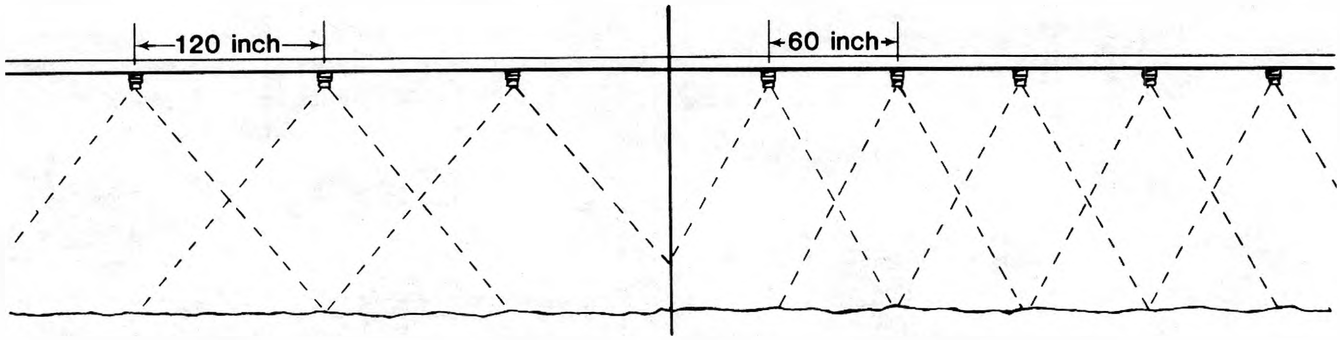


Fig. 21. If the number of nozzles on the boom are decreased by one-half then the GPA are decreased by one-half.

W = sprayed width per nozzle in inches
5940 = a constant to convert gallons per minute, miles per hour and inches to gallons per acre.

There are many methods of calibrating high-capacity sprayers, but they all utilize the variables in Equation 1. Any technique for calibration that provides accurate and uniform application can be used. No single method is best for everyone.

IV. HOW DO I SELECT THE PROPER TIP SIZE?

Custom applicators apply a variety of chemicals over a wide range of application rates. Therefore, many different nozzle tip sizes must be available and the correct tip size must be selected for each application. Quick couplers and nozzles with quick-tach adapters make it easy to change a complete set of nozzles in a very short time.

The size of nozzle tip selected depends on the application rate (GPA), travel speed (MPH), and effective spray width (W) you plan to use. Some custom applicators refer to certain "gallons-per-acre" nozzles but this rating is useful only for standard conditions (such as 20 PSI, 10 MPH, and 60 inch nozzle spacings). The gallons-per-acre rating is useless if your conditions vary from the standard.

A surer way of choosing the correct nozzle tip is to determine the gallons-per-minute (GPM) required for your conditions. Then select nozzles that, when operated within the recommended pressure range, provide this flow rate.

There are five basic steps in selecting the correct nozzle tip size.

Step 1. Select the spray application rate in gallons per acre (GPA) you want to use. Pesticide labels recommend ranges for various types of equipment. The spray application rate is the gallons of carrier (water, fertilizer, etc.) plus pesticide applied per treated area (Fig. 22).

Fig. 22. Spray application rates in gallons per acre (GPA) can be found on pesticide container labels.

Step 2. Select or measure an appropriate ground speed in miles per hour (MPH) according to existing field conditions. Do not rely on speedometers as an accurate measure of speed. Slippage and variation in tire sizes can result in speedometer errors of 30 percent or more. If actual ground speed is not known, it can be easily measured (see section on Ground Speed Measurement).

Step 3. Determine the sprayed width per nozzle in inches (W).

For broadcast spraying, W = nozzle spacing;
For band spraying, W = the band width;
For row-crop applications, such as spraying from drop pipes or directed spraying

$$W = \frac{\text{row spacing (or band width)}}{\text{number of nozzles per row (or band)}}$$

Step 4. Determine the flow rate required from each nozzle in gallons per minute (GPM) by using a nozzle catalog, tables, or the following equation:

$$GPM = \frac{GPA \times MPH \times W}{5940} \qquad \text{(Equation 2)}$$

where GPM = gallons per minute of output required from each nozzle
GPA = gallons per acre from Step 1
MPH = miles per hour from Step 2
W = inches sprayed per nozzle from Step 3

Step 5. Select a nozzle that will give the flow rate determined in Step 4 when it is operated within the recommended pressure range. Catalogs listing the flow rate at various pressures for each nozzle type and size are available from nozzle manufacturers (Tables 4, 5, 6). At this point, you may decide to use another operating speed in order to use nozzles you already have. If so, return to Step 2 and repeat the selected speed that allows you to operate within the recommended pressure range.

Example nozzle tip selection problem

You want to broadcast a herbicide at 20 GPA (Step 1) at a speed of 10 MPH (Step 2) using flooding nozzles spaced 60 inches apart on the boom (Step 3). What nozzle tip should you select?

The required flow rate for each nozzle (Step 4) is:

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

$$GPM = \frac{20 \times 10 \times 60}{5940} = \frac{12000}{5940} = 2.0$$

The nozzle you select must have a flow rate of 2.0 GPM when operated within the recommended pressure range of 8 to 25 PSI. In a Spraying Systems or Delavan nozzle catalog you will find that a TK15 or D15 nozzle respectively has a rated output of 2.0 GPM at a pressure between 10 and 20 PSI (Step 5). Therefore, either of these nozzles can be purchased for this application (Table 5).

Table 4. Regular Flat Fan Nozzles

Delavan Tip No.	Spraying Systems Tip No.	Liquid Pressure in psi	Capacity 1 Nozzle in GPM
LF-67 (100 mesh)	800067 (100 mesh)	20	.05
		25	.055
		30	.06
		40	.067
		50	.07
LF-1 (100 mesh)	8001 (100 Mesh)	20	.07
		25	.08
		30	.09
		40	.10
		50	.11
LF-1.5 (100 mesh)	80015 (100 mesh)	20	.11
		25	.12
		30	.13
		40	.15
		50	.17
LF-2 (50 mesh)	8002 (50 mesh)	20	.14
		25	.16
		30	.17
		40	.20
		50	.23
LF-3 (50 mesh)	8003 (50 mesh)	20	.21
		25	.24
		30	.26
		40	.30
		50	.34
LF-4 (50 mesh)	8004 (50 mesh)	20	.28
		25	.32
		30	.35
		40	.40
		50	.45
LF-5 (50 mesh)	8005 (50 mesh)	20	.35
		25	.40
		30	.43
		40	.50
		50	.56
LF-6 (50 mesh)	8006 (50 mesh)	20	.42
		25	.47
		30	.52
		40	.60
		50	.67
LF-8 (50 mesh)	8008 (50 mesh)	20	.57
		25	.63
		30	.69
		40	.80
		50	.89
LF-10	8010 (no strainer)	20	.71
		25	.79
		30	.87
		40	1.00
		50	1.12
LF-15	8015 (no strainer)	20	1.06
		25	1.19
		30	1.30
		40	1.50
		50	1.68

Table 5. Flooding Flat Fan Nozzles

Delavan Tip No.	Spraying Systems Tip No.	Liquid Pressure in psi	Capacity 1 Nozzle in GPM
D.5	TK.50 (100 mesh)	10	—
		20	.07
		30	.08
		40	.10
D.75	TK.75 (100 mesh)	10	.075
		20	.11
		30	.13
		40	.15
D1	TK1 (100 mesh)	10	.10
		20	.14
		30	.17
		40	.20
D1.5	TK1.5 (50 mesh)	10	.15
		20	.21
		30	.26
		40	.30
D2	TK2 (50 mesh)	10	.20
		20	.28
		30	.35
		40	.40
D2.5	TK2.5 (50 mesh)	10	.25
		20	.35
		30	.43
		40	.50
D3	TK3 (50 mesh)	10	.30
		20	.42
		30	.52
		40	.60
D4	TK4	10	.40
		20	.57
		30	.69
		40	.80
D5	TK5	10	.50
		20	.71
		30	.87
		40	1.0
D7.5	TK7.5	10	.75
		20	1.1
		30	1.3
		40	1.5
D10	TK10	10	1.0
		20	1.4
		30	1.7
		40	2.0
D15	TK15	10	1.5
		20	2.1
		30	2.6
		40	3.0
D20	TK20	10	2.0
		20	2.8
		30	3.5
		40	4.0
D30	TK30	10	3.0
		20	4.2
		30	5.2
		40	6.0

Table 5. Continued

Delavan Tip No.	Spraying Systems Tip No.	Liquid Pressure in psi	Capacity 1 Nozzle in GPM
F35	K35	10	3.5
		20	5.0
		30	6.1
		40	7.0
F40	K40	10	4.0
		20	5.7
		30	6.9
		40	8.0
F45	K45	10	4.5
		20	6.4
		30	7.8
		40	9.0
F50	K50	10	5.0
		20	7.1
		30	8.7
		40	10.0
F60	K60	10	6.0
		20	8.5
		30	10.4
		40	12.0
F70	K70	10	7.0
		20	9.9
		30	12.1
		40	14.0
F80	K80	10	8.0
		20	11.3
		30	13.9
		40	16.0
F90	K90	10	9.0
		20	12.7
		30	15.6
		40	18.0
F100	K100	10	10.0
		20	14.1
		30	17.3
		40	20.0
F120	K120	10	12.0
		20	17.0
		30	20.8
		40	24.0
F180	K180	10	18.0
		20	25.5
		30	31.2
		40	36.0
F210	K210	10	21.0
		20	29.7
		30	36.4
		40	42.0
—	K450	10	45.0
		20	63.6
		30	77.9
		40	90.0

Table 6. Hollow cone nozzles—disc and core type.

Delavan Tip No.	Spraying Systems Tip No.	Liquid Pressure in psi	Capacity 1 Nozzle in GPM
DC2-13	D2-13	40	.08
		60	.10
		80	.11
		100	.12
		150	.14
DC2-23	D2-23	40	.10
		60	.13
		80	.14
		100	.16
		150	.19
DC3-23	D3-23	40	.12
		60	.14
		80	.16
		100	.18
		150	.21
DC2-25	D2-25	40	.16
		60	.19
		80	.22
		100	.25
		150	.29
DC3-25	D3-25	40	.19
		60	.23
		80	.26
		100	.29
		150	.35

Table 6. Continued

Delavan Tip No.	Spraying Systems Tip No.	Liquid Pressure in psi	Capacity 1 Nozzle in GPM
DC3-45	D3-45	40	.23
		60	.28
		80	.33
		100	.36
		150	.44
DC4-25	D4-25	40	.29
		60	.35
		80	.40
		100	.45
		150	.54
DC5-45	D5-45	40	.45
		60	.55
		80	.64
		100	.71
		150	.86
DC7-25	D7-25	40	.52
		60	.63
		80	.73
		100	.81
		150	.98
DC6-45	D6-45	40	.58
		60	.72
		80	.83
		100	.93
		150	1.15

V. HOW DO I CALIBRATE MY HIGH-CAPACITY FLOTATION SPRAYER?

Maintaining uniform spray patterns and accurate rates is vital for precise application. Measuring actual nozzle flow rate is the only way to assure accurate calibration. Actual nozzle flow rates may not be the same as those shown in nozzle catalogs. This may be due to nozzle wear, inaccurate pressure measurement, pressure drop in booms and check valves, and flow variations due to viscosity of the spray material such as fertilizer suspensions. In practice, pressure is often measured several feet from the nozzle and line losses of 5 to 10 PSI between the gage and the nozzle are not uncommon. Even if pressure readings are taken at the nozzle, tests have shown that the actual flow rate for a moderately viscous fertilizer suspension to be 10 percent below those shown in nozzle catalogs. More discrepancy would occur with a more viscous suspension. Presently there is no good method of correcting flow rate predictions for viscosity changes so custom applicators must measure actual flow rates with the materials they will be applying.

Measuring flow rates from high-capacity nozzles requires effort but it is necessary to assure uniform and accurate calibration. Flow rate measurements can be simplified with the use of the calibration device shown in Fig. 23. Before installing the calibration device, adjust the sprayer as it will be used in the field. Check the pattern uniformity by spraying over a smooth surface. Adjust the boom height (Fig. 24), nozzle spacing, and nozzle orientation so at least 100 percent overlap is obtained at the lowest pressure you plan to operate. Record the nozzle arrangement and pressure yielding correct overlap for future reference.

Step 1. Install the calibration device between one nozzle on the boom. Operate the sprayer at the

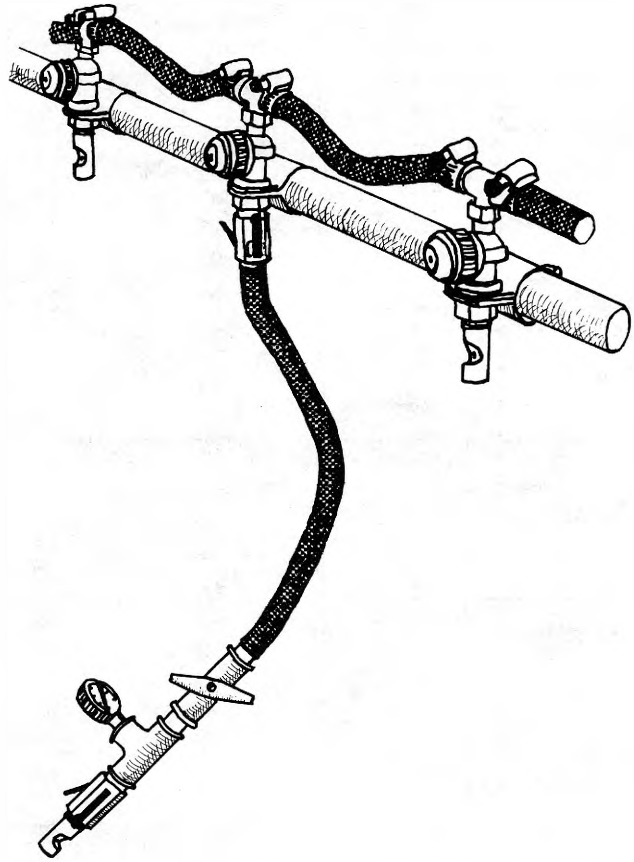


Fig. 23. High-capacity flow rate calibration device.

pressure you plan to use in the field and record the pressure drop between the pressure gage used by the operator and the gage on the calibration device. The pressure drop will be insignificant on many sprayers. Others, which sense pressure away from the nozzles, may have a pressure drop of 5 PSI or more.

Step 2. Switch off or plug all nozzles except the one in the calibration device. Collect the nozzle output for a measured time such as one minute. For volumetric measurements the container (5 to 55 gallon) should be marked in 1/4 gallon increments. A scale is needed if the containers are to be weighed.

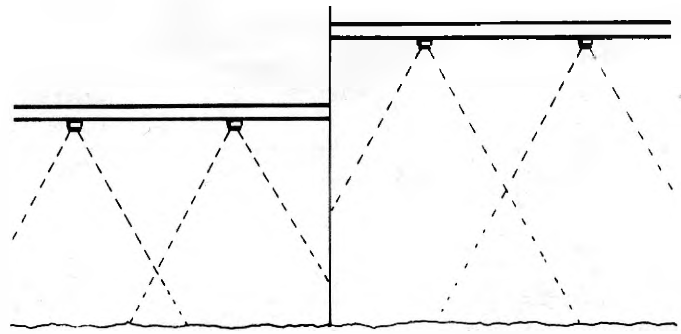


Fig. 24. Maintain proper boom height at all times, to obtain adequate coverage and minimize drift.

Check the output of each nozzle to determine an average flow rate. Replace nozzles having an output of 5 percent more or less than the average of the nozzles. Even new nozzles will differ in capacity. Nozzles normally should be replaced as a complete set since a new nozzle would not have the same flow rate as partially worn nozzles (Fig. 25).

Step 3. Once you know the average flow rate (GPM) from nozzles on the boom your operating parameters or calibration set point can be determined. This can be done in at least three ways but each utilizes the variables in Equation 1—application rate (GPA), nozzle flow rate (GPM), travel speed (MPH), and nozzle spacing (W).

a. Normally, custom applicators want to apply a desired application rate (GPA) at a set travel speed (MPH) and nozzle spacing (W). This requires knowing the pressure that provides the correct flow rate (GPM). Equation 2 from the previous section on nozzle tip selection can be used to calculate the required flow rate:

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

If the average flow rate measured in Step 2 is not equal to the required flow rate, the pressure should be varied until the amount collected is equal to the amount required.

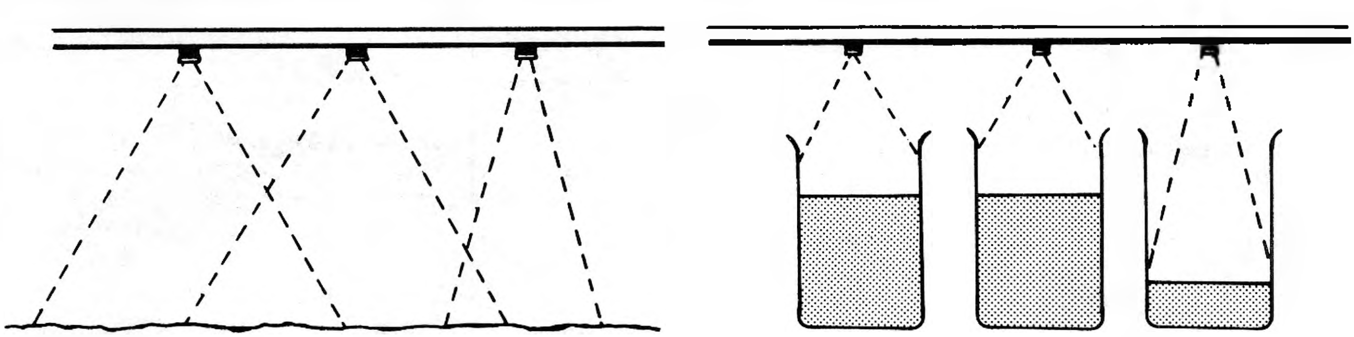


Fig. 25. Use containers to check uniform output of all the nozzles.

Example: A custom applicator wants to apply 25 GPA, at 10 MPH, using flooding nozzles on 60 inch spacings. What nozzle and pressure are required to obtain the correct flow rate?

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

$$= \frac{25 \times 10 \times 60}{5940}$$

$$= \frac{15000}{5940} = 2.5$$

From nozzle catalogs, a number 20 flooding tip has an output of 2.0 GPM at 10 PSI and 2.8 GPM at 20 PSI (Table 3). Install the tip and adjust the pressure until you collect the required 2.5 GPM. During the season, frequently check the output and adjust the pressure for changes in output due to nozzle wear and other factors.

b. Equation 1 can be used to determine the application rate (GPA) for a set travel speed, flow rate (GPM), and nozzle spacing (W).

$$GPA = \frac{GPM \times 5940}{MPH \times W}$$

Example: What is the application rate from flotation sprayer having a nozzle output of 3.4 GPM, when traveling at 12 MPH with Raindrop nozzles spaced on 60 inch centers?

$$GPA = \frac{GPM \times 5940}{MPH \times W}$$

$$= \frac{3.4 \times 5940}{12 \times 60}$$

$$= \frac{20196}{720} = 28$$

c. Equation 1 or 2 can be rearranged to calculate the required travel speed (MPH) to apply a desired application rate (GPA) for a set nozzle output (GPM) and nozzle spacing (W).

$$MPH = \frac{GPM \times 5940}{GPA \times W}$$

Example: You have measured the output from flooding nozzles on a pickup sprayer to be 2.2 GPM at 25 PSI. The nozzles are on 40 inch spacings. Desired application rate is 40 GPA. What travel speed is required?

$$MPH = \frac{GPM \times 5940}{GPA \times W}$$

$$= \frac{2.2 \times 5940}{40 \times 40}$$

$$= \frac{13068}{1600} = 8.2$$

An alternative to using the above equations for each application is to make tables or graphs of the application rate at a number of speeds for a given nozzle at several pressures. This procedure is commonly used by nozzle manufacturers. However, tables or graphs furnished by manufacturers must be modified for your pressure and flow rate results since they may differ from those given in tables or graphs. Another method for using calibration results is to enter the data into a programmable calculator or computer system.

VI. HOW IS GROUND SPEED MEASURED?

Ground speed must be accurate for precise application of pesticides. Do not rely on speedometers as an accurate measure of speed. Slippage alone can result in speedometer reading errors of 30 percent or more. Speedometer kits are available that do not use drive wheels for speed measurements. Changes in tire size affect speedometer readings, and the accuracy of all speedometers should be periodically checked.

To check your ground speed, lay out a known distance in the field to be sprayed or in a field with similar conditions (Fig. 26, 27). Suggested distances

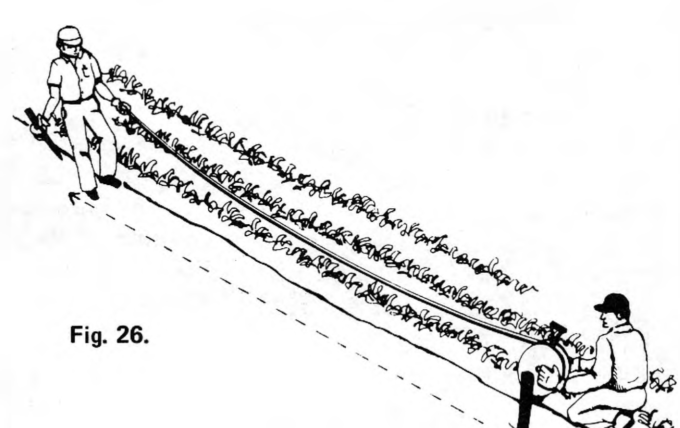


Fig. 26.

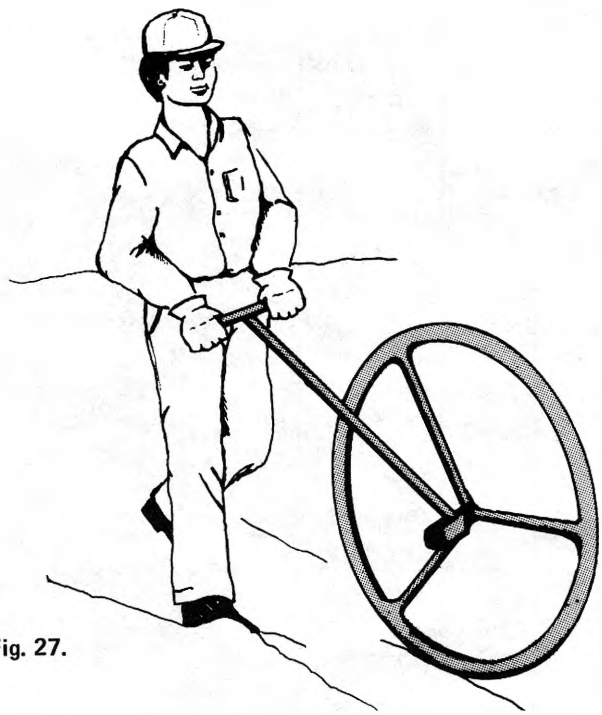


Fig. 27.

Figs. 26 and 27. Measure the distance to be used to determine the ground speed accurately by using a measuring tape or a measuring wheel.

are: 200 feet for speeds up to 5 MPH; 400 feet for speeds from 5 to 10 MPH; and 800 feet for speeds above 10 MPH. At the engine RPM and gear you plan to use during spraying with a loaded sprayer, determine the travel time between the measured stakes in each direction. Average these speeds and use the following equation or Table 7 to determine travel speed.

$$\text{Speed (MPH)} = \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$$

Example: You measure out a 400-foot course and find it required 31 seconds for the first pass and 29 seconds for the return pass.

$$\text{Average time} = \frac{29 + 31}{2} = 30 \text{ seconds}$$

$$\text{MPH} = \frac{400 \times 60}{30 \times 88} = \frac{24000}{2640} = 9.1$$

Once you have decided upon a particular speed, record the engine RPM and drive gear used.

Table 7. Travel Speeds

Speed in MPH (Miles per hour)	Time required in SECONDS to travel a distance of: 200 feet	400 feet	800 feet
5.0	27	54	108
6.0	23	46	92
7.0	19	39	78
8.0	17	34	68
9.0	15	30	60
10.0		28	56
12.0		23	44
15.0		18	36
20.0			27
25.0			22

VII. HOW MUCH CHEMICAL SHOULD I PUT IN THE SPRAY TANK?

To determine how much pesticide to add to your spray tank, you must know three things:

1. The recommended pesticide rate
2. The capacity of the spray tank
3. The calibrated output of the sprayer

The rate of pesticide to apply is determined from the label or University recommendations. The rate is usually given as pounds per acre for wettable powders and pints, quarts, or gallons per acre for liquids. Sometimes the recommendation is given as pounds of active ingredient (lb. a.i.) per acre rather than amount of product per acre. The active ingredient must be converted to actual product in this case.

You should verify that the sight gage marks are accurate for your spray tank. Misapplications occur because tank capacities are measured inaccurately. To determine tank capacity, add measured volumes of water (5 to 50 gallons) and mark the level of the measured volumes as you fill the tank. Flow meters are available to measure the quantity of water as it goes into the tank. They are much easier to use than "buckets" when calibrating size gage marks on large tanks.

The calibrated output of your sprayer determines the gallons per acre that will be applied. Pesticide labels recommend ranges of application rates for various types of equipment. Sometimes pesticides are applied in fertilizer solutions and the desired rate of fertilizer determines the required gallons per acre to apply.

Example: A farmer wants you to apply his herbicides and 120 lb. of actual nitrogen per acre.

You have a 28% nitrogen solution available that weighs 11.5 lb./gal. How many GPA of nitrogen carrier is required to apply the required rate of nitrogen?

Each pound of your nitrogen has only 0.28 lb. of actual nitrogen. Therefore, to apply 120 lb. of actual nitrogen you need to apply:

$$\frac{120 \text{ lb./A}}{.28} = 428.6 \text{ lb. of solution per acre}$$

Since your solution has a density of 11.5 lb. per gal. the required GPA is:

$$\frac{428.6 \text{ lb./A}}{11.5 \text{ lb./gal.}} = 37.3 \text{ GPA}$$

Once you know the exact capacity of your tank and have your sprayer accurately calibrated, you can determine how many acres you can spray with every tankful of spray solution. Divide the number of gallons the tank holds by the number of gallons per acre that you intend to apply. The amount of pesticide to add to the tank is determined by multiplying the acres sprayed per tankful times the recommended pesticide rate. Following are some sample problems.

Example: Dry Formulation

An atrazine recommendation calls for 2 pounds of active ingredient per acre. You have purchased AAtrex (80% wettable powder). Your sprayer has a 1200 gallon tank and is calibrated to apply 40 gallons per acre. How much AAtrex should you add to the spray tank?

Step 1. Determine the number of acres you can spray with each tankful. Your sprayer has a 400-gallon tank and puts out 20 gallons per acre.

$$\frac{\text{tank capacity (gallons per tank)}}{\text{spray rate (gallons per acre)}} = \frac{1200}{40}$$

= 30 acres sprayed with each tankful

Step 2. Determine the pounds of pesticide product needed per acre. Since not all of the atrazine in the bag is an active ingredient, obviously you will have to add more than 2 pounds of the product to each "acre's worth" of water in your tank. How much more? The calculation is simple--divide the percentage of active ingredient (in this case 80) into the total (100).

$$2 \text{ lb. a.i. per acre} \times \frac{100\%}{80\%} = 2 \times 1.25 =$$

2.5 lb. of product per acre

So, 2.5 pounds of product is needed for each "acre's worth" of water in the tank to apply 2 pounds of active ingredient per acre.

Sometimes one gets confused and wonders, "Do I divide the 100 by 80 or is it the other way around?" This is where common sense comes in. The label tells you that the commercial material in the bag is not 100 percent active ingredient--it is only 80 percent. Logic then suggests that you will need some extra material. To get that extra, you have to divide the large number by the small number to get a number bigger than 1.

$$80 \text{ divided into } 100 = \frac{100}{80} = 1.25$$

Step 3. Determine the amount of pesticide to add to each tankful. With each tankful you will cover 30 acres (Step 1) and want 2.5 pounds of product per acre, (Step 2), so add 75 pounds (30 acres x 2.5 pounds per acre = 75 pounds of product) of atrazine to each tankful.

Example: Liquid Formulation

A trifluralin recommendation calls for 1 pound of active ingredient per acre. You have purchased Treflan 4E (4 lbs./gal. formulation). Your sprayer has a 2000 gallon tank and is calibrated at 40 gallons per acre. How much Treflan should you add to the spray tank?

Step 1. Determine the number of acres you can spray with each tankful. Your sprayer has a 2000 gallon tank and is calibrated for 40 gallons per acre.

$$\frac{\text{tank capacity (gallons per tank)}}{\text{spray rate (gallons per acre)}} = \frac{2000}{40}$$

= 50 acres sprayed with each tankful

Step 2. Determine the amount of product needed per acre. This is done by dividing the recommended active ingredient per acre by the concentration of the formulation.

$$\frac{1 \text{ lb. a.i. per acre}}{4 \text{ lb. a.i. per gallon}} = 1/4 \text{ gallon per acre}$$

So, 1/4 gallon or 1 quart of product is needed for each "acre's worth" of water in the tank to apply 1 pound of active ingredient per acre.

Step 3. Determine the amount of pesticide to add to each tankful. With each tankful you will cover 50 acres (Step 1) and want 1/4 gallon (1 quart) of product per acre (Step 2), so add 50 quarts (50 acres x 1 quart per acre = 50 quarts) of trifluralin to each tankful.

Example: Adjuvants (Spreader-Sticker, Surfactant, etc.)

Often you will encounter a recommendation which says that in addition to the regular chemical you should add a small amount of some adjuvant. This type of recommendation often is given as percent concentration.

If you use an adjuvant at a 1/2 percent concentration by volume, how much should you add to a 1000 gallon tank?

Solution 1:

1 percent of 100 gallons = 1 gallon (100 x .01 = 1
1/2 percent of 100 gallons = 1/2 gallon

Therefore you need 1/2 gallon per 100 gallons, or 5 gallons for 1000 gallons (1/2 x 10 = 5).

Solution 2:

1/2 percent = 0.005
0.005 x 1000 gallons = 5 gallons needed

VIII. WHAT ARE OTHER REQUIREMENTS FOR PRECISE APPLICATION?

Weed control is often poor at the edge of the field when there is no overlap from the end nozzle on the first pass around the field. One solution is to install a separate, off-center nozzle on the end of the boom (Fig. 28). That nozzle can be operated by a manual or electric valve during the first round and then shut off during application over the rest of the field. Another method is to decrease travel speed until the resulting pressure drop reduces the pattern width to single coverage with no overlap. This procedure eliminates the edge effect, but results in an uneven spray pattern across the boom

Crop damage can occur if the nozzles are allowed to drip during turns or when the sprayer is stopped for refilling or other reasons. To avoid dripping, high capacity, diaphragm nozzle check valves should be used on each nozzle. These valves give satisfactory results with minimum maintenance. When calibrating the nozzle flow rate, remember to account for the pressure drop across the valve; a 5 PSI check valve requires 25 PSI at the gage in order to have 20 PSI at the nozzle (Fig. 29).

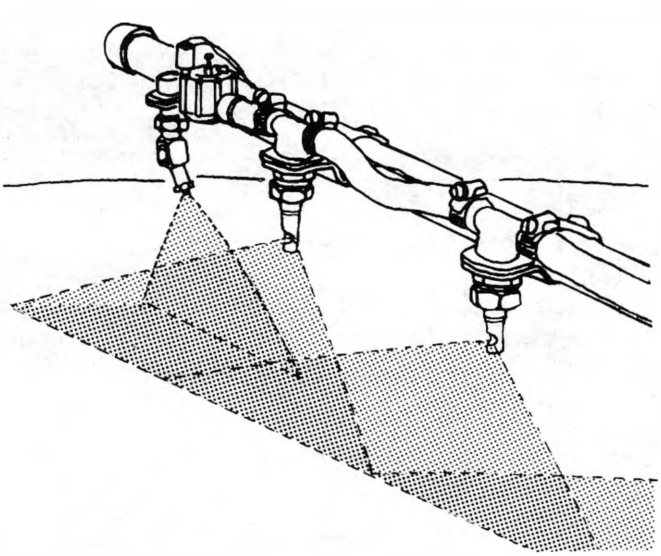


Fig. 28. For spraying the perimeter of a field an Off-Center Nozzle can be used at the end of the boom to make up the 100% overlap.

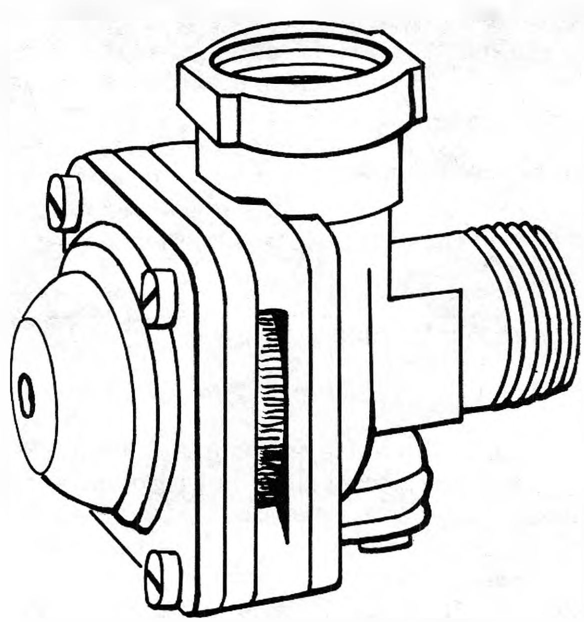


Fig. 29. To avoid dripping, high capacity diaphragm nozzle check valves should be used on each nozzle.

Marking swaths is a major problem when applying pesticides with high-speed, high-capacity flotation sprayers that have wide booms. At high speeds and long distances from the mark, achieving accuracy is so difficult that overlaps and skips can easily occur. At present, marking systems rely on the operator's skill in sighting a particular mark; sun glare, cross tillage, and simple lack of visual perception or decreased vision at night are sources of error.

Marking systems currently used include flagmen, automatic flaggers, mechanical disk markers, dyes, soaps, foams, and electric guidance systems. The most widely accepted system used by flotation operators seems to be the foam marker (Fig. 30). Current research and development activities are aimed at developing new marking systems that use recent electronic advances, such as light-sensing, rotating lasers and radio-controlled guidance systems.

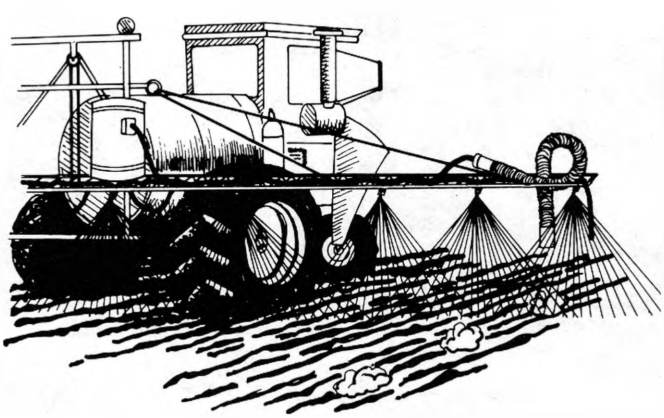


Fig. 30. The most widely accepted marking system used by flotation operators seems to be the foam marker.

The AgNav system recently introduced uses radio signals to track and guide the operator by means of a continuous display on the dashboard. The concept has tremendous potential for reducing overlap and skips, but operator experience will be required to determine electronic reliability under field conditions.

Drift and Coverage

Preplant and preemergence applications of herbicides and soil-applied insecticide do not require a large number of droplets per square inch for good pest control. Therefore, high pressures for maximum droplet breakup are not needed. Emphasis should be placed on using only enough pressure to obtain good spray patterns. Lower pressures result in larger drops that are less likely to drift if wind gusts occur.

Applicator experience indicates that 15 to 20 gallons of spray solution per acre gives sufficient coverage for most preplant and preemergence herbicides when applied in calm wind conditions. To apply pesticides in 8- to 10-MPH winds with greater safety, good applicators use nozzles with higher flow rates to apply 25 to 40 gallons of spray solution at a spraying pressure of 8 to 15 PSI. Increasing the spray volume for higher wind speeds should be done by using nozzles with higher flow rates, not by increasing the spray pressure.

Spray thickeners can be used to reduce spray drift. New long-chain polyvinyl polymers that prevent the formation of many of the small droplets are available as thickening agents. The addition of 4 to 8 ounces of the thickener per 100 gallon of spray solution will drastically reduce the amount of drift from flooding nozzles. No special equipment is required to use these thickeners, but they must be mixed according to directions.

Avoiding and Handling Herbicide Performance Complaints

Loren E. Bode

Maintaining precise application with high-capacity sprayers is more than applying the correct amount of herbicide on a field and keeping a record of the amount applied. Cropping history, tillage methods, soil and climatic conditions, fertility programs, and chemical application techniques can all affect the performance of herbicides. Although soil and weather conditions greatly influence the action of herbicides, it has been reported that most (70 to 90 percent) performance complaints of herbicide failures are directly related to errors in dosage or to improper application. A 1979 survey by Rider and Dickey showed that about 63 percent of the applicators in Nebraska had a calibration or mixing error in excess of 10 percent, and over 12 percent had both a calibration and mixing error. Commercial applicators apply about 30 percent of all herbicides, and the Nebraska survey indicated that nearly two-thirds of the commercial applicators were within 10 percent of their desired application rate.

Avoiding Complaints

The most obvious solution to handling complaints caused by misapplication is to improve our application precision. Application equipment is not always utilized to its maximum efficiency, partly because we fail to realize the importance of precise application, and partly because we do not give the time and effort necessary to apply the herbicides in the most effective manner. If we let this happen, some customers will be unsatisfied, and valuable time will be lost in handling complaints about poor weed control or crop damage. Putting more emphasis on recordkeeping and planning, herbicide and rate selection, and equipment calibration and maintenance would eliminate much of the time and money now spent in handling performance complaints.

Planning and Recordkeeping

The number of days available for applying herbicides is limited, and tremendous pressure is generated to treat as many acres per day as possible. We often cut corners, therefore, to increase output, only to find that we have decreased profitability through increased performance complaints. We need to realize that it may be more profitable to refuse to apply a herbicide under windy conditions, for example, than to spend many days settling drift complaints. Planning is one way we can eliminate many of the time constraints.

Plan to provide as much backup help as possible with refueling, washing, and general equipment maintenance and require a minimum amount of time for rest each day. Many misapplication errors are the result of operator fatigue due to lack of sleep. A well-rested alert operator will prevent--not create--performance complaints.

In general, the operator of the sprayer most influences the number of complaints that must be handled. He or she must know how, when, and where to use herbicides and under what conditions not to use a herbicide. The operator also must understand calibration and the importance of uniform application and must be able to communicate with the farmer. Moreover, the operator needs to collect as much information as possible on every application site, for example: What is the herbicide rate to use? Where is the field located and how many acres does it contain? What nozzle type, boom pressure, and travel speed are needed?

Recordkeeping is the key. It provides the operator with the information needed to avoid application errors. Recordkeeping begins at the initial discussion with the farmer concerning the herbicides and rates to be used. A detailed map of each field with notes of what is to be applied will allow the operator to compare the load he receives with what the map says.

Records may be the most important documentation available for handling a performance complaint. Often a farmer's memory of the application conditions may not be the same as the operator's, and with records you can show written evidence of the conditions at the time of application.

There are numerous record forms available that are easy to fill in and require only a small amount of time. One example is given in Figure 1. Each commercial operation is unique and you need to adapt the record form to fit your particular operation. The form should indicate where the application started, where it ended, where nursing took place, whether the application was long or short, and whether any calibration or mechanical problems occurred. All operators will make an occasional error, and it should be a part of the record.

As an example, improper amounts of herbicides might be mixed because the customer-reported acreage was different from the actual acreage. If calibration changes are necessary to complete a field or finish out a load, they should be recorded so that the actual acreage can be determined for application the following year. Keeping accurate records is the best way to verify the actual rate of herbicide applied.

Uniform Application

Although recordkeeping and planning will help an operator in avoiding misapplication of herbicides, most complaints are usually the result of nonuniform application. Therefore, following the basic procedures for applying herbicides uniformly and accurately is very important. Selecting proper nozzles and nozzle tips, calibrating the sprayer, and following the necessary application procedures in the field are all important to maintaining uniform application. Procedures for checking the quality of application and thus for avoiding complaints are simple if clearly understood by the operator.

Nozzles. Proper selection and operation of spray nozzles is the most important part of precise application. The nozzle determines the amount of spray applied to a given area, the uniformity of the applied spray, the coverage obtained on the sprayed surfaces, and the amount of drift that occurs. A conscientious applicator minimizes the drift problem by selecting nozzles that give the largest droplet size while still providing adequate coverage at the intended application rate and pressure. Although nozzles have been developed for practically every kind of spray application, only a few types are commonly used for applying herbicides to agricultural crops.

Flooding nozzles are the most commonly used nozzle type, and, when used properly, they are well suited for most applications. Uniformity of application with flooding nozzles depends on nozzle pressure, nozzle height, nozzle spacing, and nozzle orientation.

COMMERCIAL PESTICIDE APPLICATION RECORD

Patron Name ______________________ Date and Time of Application __________

Field Location ______________________ Acres Treated __________

Chemical(s) Applied	Formulation of Chemical	Rate Per Acre	Total Added To Sprayer

Carrier (water, liq. fert., etc.)	Rate Per Acre	Total Added To Sprayer

Wind Direction ______________________ Temperature __________

Wind Velocity	Soil Texture	Soil Moisture
Calm	Level, fine texture	Very wet
5-10 mph	Rough, cloddy	Wet
Over 10 mph	Plant debris on surface	Moist
		Dry

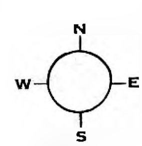
Method of Application: Preplant Pre-emergence Post emergence

Crop ______________ Stage of Crop Growth ______________

Stage of Weed or Insect Development ______________________

Comments: __________

Field Map (sketch to show field & direction of application)



Ticket No. __________

____
Applied by

____
Accepted by

Figure 1. Example of a commercial application record form.

Pressure affects application in several ways. It influences droplet size, nozzle flow rate, spray angle, and pattern uniformity. To maintain a uniform spray distribution pattern with reasonable drift control, you need to operate flooding nozzles within a pressure range of 8 to 25 pounds per square inch (psi).

Nozzle height is critical in obtaining a uniform application. Once the proper nozzle height has been determined, the travel speed must be selected according to field conditions to keep the boom from whipping back and forth or bouncing up and down. For most applications, maximum travel speeds should be 12 to 16 miles per hour rather than the speeds of 18 to 22 miles per hour that are sometimes used.

Improper overlap is a common problem resulting in nonuniform application and the need to handle complaints. To best compensate for pattern variability due to pressure, height, and spacing, use the recommended nozzle arrangement shown in Figure 2. With this arrangement, the nozzles are spaced on 40- to 80-inch centers (commonly 60 inches) and the height adjusted to obtain double coverage or 100 percent overlap. With 100 percent overlap, the individual nozzle patterns reach the center of the pattern of each adjacent nozzle and the entire surface receives spray from two nozzles. With nozzles set to obtain double coverage, small variations in pressure and height can be tolerated without resulting in unacceptable distribution patterns.

It is extremely difficult to obtain uniform distribution patterns from flooding nozzles spaced on 10-foot centers. With a pressure change from 8 to 25 psi, the patterns are not sufficiently uniform for applying herbicides. Therefore, when applying herbicides, nozzle spacing should be less than 80 inches.

The RA Raindrop® nozzle is recommended when spray drift is a major problem. When operated within a pressure range of 20 to 50 psi, the nozzle delivers a wide-angle hollow cone spray pattern and produces fewer smaller drops than the flooding nozzle. To obtain a uniform spray pattern, space the nozzle no more than 60 inches apart and rotate it from 30 to 45 degrees from the vertical axis. Large droplets produced for drift control reduce the coverage required for some foliar herbicides. When using this nozzle, adjust to obtain double coverage or 100 percent overlap.

Regular flat-fan or hollow cone nozzles are sometimes used on high-clearance and pickup sprayers and for foliar applications where better coverage is required than can be obtained from the high-capacity flooding nozzles. They are normally spaced on 20-inch centers, and overlapping of spray patterns should be about 40 to 50 percent of the nozzle spacing to obtain uniform spray distribution. At pressures from 40 to 60 psi, small drops are produced and high pressures should only be used to apply foliar herbicides that require penetration into the canopy and maximum coverage. Drift potential must be a major concern at pressures above 30 psi.

Nozzle tips are available in a variety of materials including hardened stainless steel, nylon, and brass. Hardened stainless steel is the most wear-resistant material, but the most expensive. Stainless steel, nylon, and other synthetic plastics have excellent wear resistance with either corrosive or abrasive materials. For custom application of fertilizer and herbicides to large acreages, hardened stainless steel is most likely the most cost-efficient nozzle material.

Calibration. A variety of herbicides are applied to crops over a wide range of application rates. Therefore, many different nozzle tip sizes must be available, and the correct tip size must be selected for each application. Quick couplers and nozzles with quick-tach adapters make it easy to change a complete set of nozzles in a very short time.

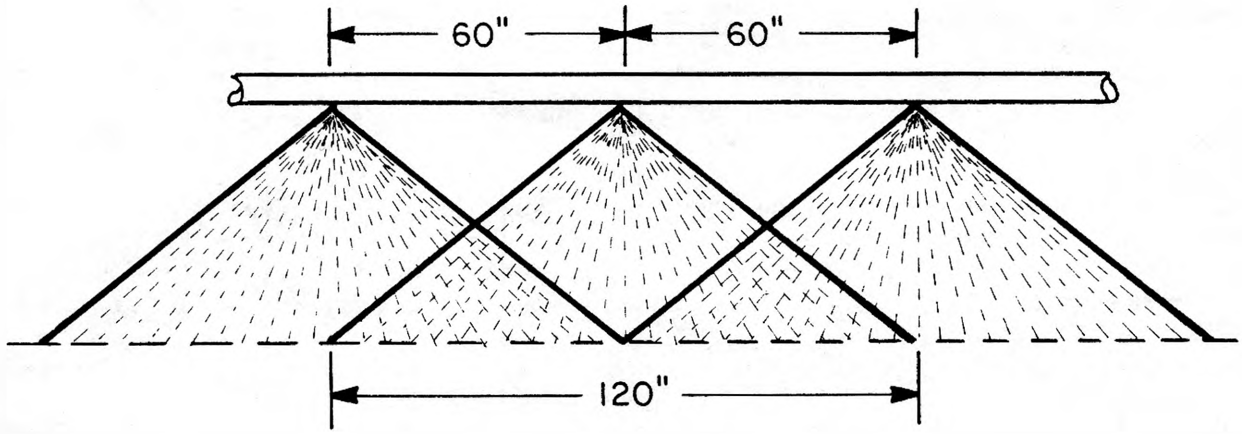


Figure 2. Recommended nozzle arrangement to obtain double coverage from flooding and Raindrop nozzles.

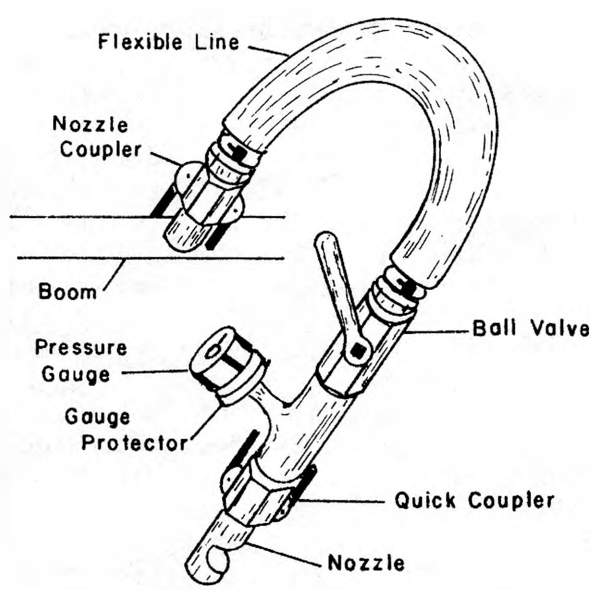


Figure 3. Calibration device to measure nozzle flow rate.

The size of the nozzle tip selected depends on the application rate (GPA), travel speed (MPH), and effective spray width (W) you plan to use. The correct tip can be chosen by determining the required flow rate (GPM) for each application. Then select nozzles that, when operated within the recommended pressure range, provide this flow rate.

Example: You want to broadcast a herbicide at 20 GPA at a speed of 10 MPH using flooding nozzles spaced 60 inches apart on the boom. What nozzle tip should you select?

The required flow rate for each nozzle is:

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

$$GPM = \frac{20 \times 10 \times 60}{5940} = \frac{12000}{5940} = 2.0$$

The nozzle you select must have a flow rate of 2.0 GPM when operated within the recommended pressure range of 8 to 25 psi. In a Spraying Systems or Delavan nozzle catalog, you will find that a TK15 or D15 nozzle, respectively, has a rated output of 2.0 GPM at a pressure between 10 and 20 psi. Therefore, either of these nozzles can be selected for this application.

Actual nozzle flow rates may not be the same as those shown in nozzle catalogs. This discrepancy may be the result of nozzle wear, inaccurate pressure measurement, pressure drop in booms and check valves, and flow variations due to the density and viscosity of the spray material, such as in fertilizer suspensions. In practice, pressure is often measured several feet from the nozzle, and line losses of 5 to 10 psi between the gage and the nozzle are not uncommon. Nozzle check valves also require an additional 5 to 7 psi pressure drop.

Density of the spray solution, especially when herbicides are applied along with fertilizers, affects the flow rate through the nozzle. Correction factors to calculate the flow rate for solutions having densities different from water are generally in the nozzle catalogs. High viscosity results in a reduction of nozzle flow rate in some suspension fertilizers. Tests have shown that the actual flow rate for a moderately viscous fertilizer suspension is 10 percent below the rate shown in nozzle catalogs. Presently there is no good method for accurately predicting flow rates. Therefore, custom applicators must measure actual flow rates with the materials they will be applying. Also, flow meters monitoring the flow to the boom cannot detect variations in flow rate between individual nozzles.

Measuring flow rates from individual nozzles requires effort, but measuring is necessary to assure uniform and accurate calibration. Flow rate measurements can be simplified with the use of a calibration device similar to that shown in Figure 3. Before installing the calibration device, adjust the sprayer as it will be used in the field. Check the pattern uniformity by spraying over a smooth surface. Adjust the boom height, nozzle spacing, and nozzle orientation so that at least 100 percent overlap is obtained at the lowest pressure you plan to operate. Record the nozzle arrangement and pressure that yield correct overlap for future reference. Because of wear, nozzles should be changed as complete sets rather than individually.

Application Procedures

Flotation sprayers generally have some type of metering system that maintains a constant gallonage per acre when the sprayer is operated over a range of travel speeds. All systems now in use vary nozzle pressure with change in travel speed to keep the gallons per acre constant. Therefore, the spray nozzle is the factor limiting the range of speeds at which precise application can be obtained.

To regulate the flow in proportion to the travel speed, you must vary the nozzle pressure by the square of the speed. In other words if an applicator is traveling at 8 MPH and is operating at a pressure of 20 psi, increasing the speed to 16 MPH requires raising the nozzle pressure to 80 psi. Keep in mind that a fourfold range in pressure drastically changes the droplet size, pattern width, and distribution pattern. Therefore, changes in speed, even when using controlled metering systems, should always be limited to maintain the nozzle pressure within the recommended range. For flooding nozzles, this would be 10 to 25 psi at the nozzle.

Crop damage can occur if the nozzles are allowed to drip during turns or when the sprayer is stopped for refilling or other reasons. To avoid dripping, use high-capacity, diaphram-nozzle check valves on each nozzle. These valves give satisfactory results with minimum maintenance. When calibrating the nozzle flow rate, remember to account for the pressure drop across the valve; a 5 psi check valve requires 25 psi at the gage in order to have 20 psi at the nozzle.

Weed control is often poor at the edge of the field when there is no overlap from the end nozzle on the first pass around the field. Decreasing nozzle pressure to obtain single instead of double overlap is sometimes used to correct this problem, but this solution can result in a nonuniform pattern across the entire width of the boom.

A better solution is to install a separate, off-center nozzle on the end of the boom. That nozzle can be operated by a manual or electric valve during the first round and then shut off during application over the rest of the field. To obtain customer satisfaction and avoid complaints, you must correct the reduced rate when spraying the perimeter of a field.

Marking swaths is a major problem when applying herbicides with high-speed, high-capacity flotation sprayers that have wide booms. At high speeds and long distances from the mark, achieving accuracy is so difficult that overlaps and skips can easily occur. Some marking systems rely on the operator's skill in sighting a particular mark; sun glare, cross tillage, the lack of visual perception, or decreased vision at night are sources of error.

Marking systems currently in use include flagmen, automatic flaggers, mechanical disk markers, dyes, soaps, foams, and electronic guidance systems. The system most widely used by flotation operators seems to be the foam marker. Current research and development activities are aimed at developing new marking systems that use recent electronic advances such as light-sensing, rotating lasers, and radio-controlled guidance systems.

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Applicator experience indicates that 15 to 20 gallons of spray solution per acre give sufficient coverage for most preplant and preemergence herbicides when applied in calm wind conditions. To apply pesticides in 8 to 10 MPH winds with greater safety, good applicators use nozzles with higher flow rates to apply 25 to 40 gallons of spray solution at a spraying pressure of 8 to 15 psi. Increasing the spray volume for higher wind speeds should be done by using nozzles with higher flow rates, not by increasing the spray pressure.

Spray thickeners can be used to reduce spray drift. New long-chain polyvinyl polymers that prevent the formation of many of the small droplets are available as thickening agents. The addition of four to eight ounces of the thickener per 100 gallons of spray solution will drastically reduce the amount of drift from flooding nozzles. No special equipment is required to use these thickeners, but they must be mixed according to directions.

Handling Complaints

In spite of conscientious efforts to prevent complaints, you will still have some, and they must be handled quickly, quietly, and professionally. Proper handling of herbicide complaints is very important to a successful custom application business.

Considerable skill is required to "listen" to the customer and maintain a good relationship while determining the cause of the complaint. A positive attitude toward helping the customer is a key to successful handling of a complaint. When a complaint is received, make arrangements to meet with the customer personally at the earliest possible time. Prompt and personal attention indicates a real desire to help find the cause of the failure. Diagnosis by phone or delay in responding indicates to the customer that his problem is not really not worth your time and effort.

Proper diagnosis of a complaint, whether it is for poor herbicide performance, crop damage, or off-target drift injury requires assimilation of many variables. For example, herbicide streaking is a common complaint, but it can be caused by many factors, including improper swath marking, improper nozzle overlap, worn or plugged nozzles, boom instability, tillage or incorporation techniques, and residue distribution. When checking a complaint about streaking, compare the streaking pattern with the nozzle spacing, boom width, width of tillage tools, tractor tire spacing, and combine header width. For example, on several occasions it has been determined that streaking occurred from the crop residue being placed in a narrow windrow during harvest. The residue absorbed a sufficient amount of herbicide to cause streaking. Compaction from tractor tires during tillage is also a common cause of streaking as is improper incorporation. Insufficient soil mixing from reduced passes, improper equipment settings, or incorporation under wet or dry soil conditions will cause weed streaking. Check the soil conditions (roughness, cloddiness, and residue level) that existed at the time of application and incorporation. Knowing the direction of travel during incorporation can also help determine whether the streaks are a result of poor incorporation.

Poor weed control or crop damage around the edge of the field is another common complaint. This problem is often the result of tillage, compaction, or fertility changes, but it can be the result of improper application. Check to see that an extra nozzle was installed when the perimeter of the field was sprayed to fill in the pattern that is normally overlapped from the next pass.

Allowing nozzles to drip during turns or double applications at the ends of a field also can result in crop damage. Spills during loading are often the source of damage; check your records for the location of nursing at the time of application.

Inconsistent weed control may be the result of varying soil types within the field, but it also can be due to improper tank agitation or speed variations during application. Try to relate patterns of weed control to the beginning and end locations of individual loads. After herbicides were added to the tank, sufficient time should have been allowed to completely mix the solution; otherwise, poor control will be noticeable for a distance where each new load began. If agitation was insufficient to maintain the herbicide in suspension, crop damage may show up where the tank was nearly empty during application. On the other hand, if a tank of solution was allowed to sit for a time without agitation, overapplication may have occurred during the first pass.

Drift complaints require more detailed information on humidity, temperature, wind speed and direction, nozzle type and pressure, application rate, and other factors. Accurate records of wind speed and direction during application can indicate whether off target damage was the result of your application or not. Check your records to see if barrier strips were used and then were sprayed later.

Restricted-Use and Illinois State-Labeled Pesticides

C.W. MacMonegle and C.E. Colwell

The legal mechanism for restricting the use of certain pesticides was introduced in the 1972 amendments to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Confronted with the enormous task of reviewing all registered pesticides, the U.S. Environmental Protection Agency (EPA) proposed to classify pesticides by their active ingredients, subdividing each active ingredient into its various formulations or uses. This classification system gave the EPA more flexibility to restrict some but not all products containing the same active ingredient. This process was called classification by regulation. When pesticides are restricted in this manner, the manufacturer is given 270 days to amend the label on all of the affected products. This timetable has been of particular interest to pesticide dealers because, once the restricted use label is applied to the container, it can be sold only to a certified applicator.

In addition to reviewing existing products, the EPA has to register new products never before marketed. Some of these new products have been classified for restricted use. This process is called classification by registration.

Pesticides classified for restricted use by registration and regulation are listed in Table 1.

When the FIFRA law was amended, a special section (24c) was included that allowed state lead agencies to register specific products for special local needs within the state. The Illinois Department of Agriculture currently has over 50 state-labeled pesticides commonly referred to as 24(c)'s or SLN's. Table 2 lists the current 24(c) registrations in Illinois. Applicators who wish to apply a pesticide under a 24(c) must have a copy of the Illinois label in their possession at the time of application.

Table 1. Restricted-Use Pesticides (1982)

Active ingredient	Trade name	Type	Formulation	Use	Criteria for restricted use
acrolein	Aqualin	aquatic herbicide	all formulations	all uses	acute inhalation toxicity, residue effects on birds and aquatic organisms
acrylonitrile	Acritet	fumigant	all formulations	all uses	accident history
aldicarb	Temik	insecticide	all formulations	ornamental uses	accident history
allyl alcohol		herbicide	all formulations	all uses	acute dermal toxicity
aluminum phosphide . .	Phostoxin, Detia	fumigant	all formulations	all uses	acute inhalation toxicity
amitraz	Tuco BAAM 50W	herbicide	only product	all uses	--
azinphosmethyl	Guthion	insecticide	all liquids with concentrations above 13.5%	all uses	acute inhalation toxicity
brodifacoum	Talon G Rodenticide Pellets, Rodenticide Bait Pack	rodenticide	only product	all uses	nontarget effects
bromadiolone	Maki Urban Rat and Mouse Meal Bait	rodenticide	only product	all uses	restricted at registration
calcium cyanide . . .	Cyanogas	fumigant	all formulations	all uses	acute inhalation toxicity
carbofuran	Furadan	insecticide	all concentrate suspensions and wettable powders greater than 40%	all uses	acute inhalation toxicity
chlordimeform	Galecron, Fundal	insecticide	all formulations	all uses	restricted at registration
chlorfenvinphos . . .	Birlane	insecticide	all formulations	all uses	acute dermal toxicity
chlorobenzilate . . .		insecticide	all formulations	all uses	restricted at registration
chloropicrin	many	fumigant	all formulations greater than 2%	all uses	acute inhalation toxicity
chloropicrin	many	fumigant	all formulations	rodent control	acute inhalation toxicity
chlorpyrifos	Killmaster	insecticide	2% in lacquer base	all uses	restricted at registration
chlonitralid	Bayluscide	molluscide	all granular and wettable powders	all uses	acute inhalation toxicity, effects on aquatic organisms
cycloheximide	Acti-dione	fungicide	all formulations greater than 4%	all uses	acute dermal toxicity
demeton	Systox	insecticide	all formulations	all uses	acute oral and dermal toxicity, residue effects on birds and mammals
dichlofop	Hoelon	herbicide	all formulations	all uses	conditional registration
dicrotophos	Bidrin	insecticide	all liquid formulations 8% or greater	all uses	acute dermal toxicity, residue effects on birds
diflubenzuran	Dimilin	insecticide	all formulations	all uses	effects on nontarget organisms
dioxathion	Delnav, Deltic	insecticide	all concentrate solutions and emulsifiable concentrates	all uses	acute dermal toxicity
dioxathion	Delnav	insecticide	all solutions greater than 3%	domestic uses	acute dermal toxicity
disulfoton	Di-Syston	insecticide	all emulsifiable concentrates and concentrate solutions	all uses	acute dermal and inhalation toxicity

Table 1. (Continued)

Active ingredient	Trade name	Type	Formulation	Use	Criteria for restricted use
disulfoton	Di-Syston	insecticide	all nonaqueous solutions	commercial seed treatment	acute dermal and inhalation toxicity
disulfoton	Di-Syston	insecticide	granular formulations greater than 10%	indoor uses	acute dermal and inhalation toxicity
endrin		insecticide	all formulations	all uses	acute dermal toxicity, effects on non-target organisms
EPN		insecticide	all formulations greater than 4%	all uses	acute dermal toxicity, residue effects on mammals and aquatic organisms
ethoprop	Mocap	insecticide	emulsifiable concentrates	all uses	acute dermal toxicity
ethyl parathion . . .		insecticide	all formulations	all uses	acute dermal and inhalation toxicity, effects on birds, fish, and mammals
fenamiphos	Nemacur	nematicide	emulsifiable concentrates	all uses	acute dermal toxicity
fensulfothion	Dasanit	insecticide	emulsifiable concentrates and concentrate solutions	all uses	acute dermal and inhalation toxicity
fensulfothion	Dasanit	insecticide	granular formulations	indoor uses	acute dermal and inhalation toxicity
fenvalerate	Pydrin	insecticide	emulsifiable concentrates	cotton	high fish toxicity
fluoroacetamide . . .	1081	rodenticide	all formulations	all uses	acute dermal toxicity
fonofos	Dyfonate	insecticide	emulsifiable concentrates greater than 44%	all uses	acute dermal toxicity
heptachlor		insecticide	all formulations	all uses	administrative order
hydrocyanic acid . . .	HNC	fumigant	all formulations	all uses	acute inhalation toxicity
isofenphos	Amaze	insecticide	all formulations	all uses	conditional registration
magnesium phosphide .		fumigant	all formulations	all uses	acute inhalation toxicity
methiocarb	Borderland Black Repellent, Hopkins Mesrepel, Mesurol	bird repellent	all formulations	all uses	restricted at registration, non-target effects
methamidophos	Monitor	insecticide	all liquid formulations 40% or greater, dust formulations 2.5% or greater	all uses	acute dermal toxicity, residue effects on birds
methidathion	Supracide	insecticide	all formulations	all uses except nursery sunflowers and safflowers	residue effects on birds
methomyl	Lannate, Nudrin	insecticide	1-2.5% baits except 1% fly bait	all uses	residue effects on mammals, accident history
methomyl	Lannate, Nudrin	insecticide	all concentrated solution formulations	all uses	residue effects on mammals, accident history
methomyl	Lannate, Nudrin	insecticide	90% wettable powder not in water-soluble bags	all uses	residue effects on mammals, accident history
methyl bromide	many	fumigant	all formulations in containers heavier than 1.5 pounds	all uses	accident history, acute inhalation toxicity
methyl bromide	many	fumigant	all formulations in containers lighter than 1.5 pounds with no indicator	all uses	accident history, acute inhalation toxicity

Table 1. (Continued)

Active ingredient	Trade name	Type	Formulation	Use	Criteria for restricted use
methyl parathion . . .		insecticide	all formulations	all uses	acute dermal toxicity, residue effects on birds, bees and mammals
mevinphos	Phosdrin	insecticide	all formulations	all uses	acute dermal toxicity, residue effects on birds and mammals
monocrotophos	Azodrin	insecticide	liquid formulations	all uses	residue effects on birds and mammals
nicotine		insecticide	all formulations	cranberries	acute inhalation toxicity, effects on aquatics
nicotine		insecticide	all formulations 14% or greater	all indoor (greenhouse) uses	acute inhalation toxicity
nitrofen		herbicide	all formulations	all uses	chronic effects
paraquat	Paraquat	herbicide	all formulations except those listed in footnote*	all uses	use and accident history
pendimethain	Pay-Off	insecticide	only product	all uses	nontarget effects
permethrin	Ambush, Pounce	insecticide	emulsifiable concentrates	cotton	high fish toxicity
phorate	Thimet	insecticide	liquid formulations	all uses	acute dermal toxicity, residue effects on birds and mammals
phorate	Thimet	insecticide	granular formulations	rice	acute dermal toxicity, residue effects on birds and mammals
phosacetim		rodenticide	baits	all uses	residue effects on birds and mammals
phosphamidon	Dimecron	insecticide	all formulations	all uses	acute dermal toxicity, residue effects on birds and mammals
picloram	Tordon	herbicide	all formulations except Tordon 101R	all uses	effects on nontarget plants
pronamide		herbicide	all formulations not in water-soluble bags	all uses	oncogen
propetamphos	Safrotrin E.C. Insecticide	insecticide	only product	all uses	voluntary restriction
rozol-blue	Rozol Blue Tracking Powder	rodenticide	all formulations	all uses	effects on nontarget organisms
sodium cyanide		fumigant	all formulations	all uses	acute inhalation toxicity
sodium flouroacetate .	1080	rodenticide	all formulations	all uses	acute oral toxicity, use and accident history
starlicide	Gull-Toxicant 98% Concentrate	bird repellent	only product	all uses	nontarget effects
strychnine		rodenticide	all formulations greater than 0.5%	all uses	acute oral toxicity, effects on nontarget organisms, accident history
strychnine		rodenticide	all formulations less than 0.5%	all uses except subsoil uses	acute oral toxicity, effects on nontarget organisms, accident history
sulfotepp	Bladafume	fumigant	all formulations	all uses	acute inhalation toxicity
sulprofos	Bolstar	insecticide	all formulations	all uses	restricted at registration

*Pressurized spray can with 0.44% paraquat and 15% petroleum distillate as active ingredient; liquid fertilizer with 0.025% paraquat and 3% paraquat and 0.37% atrazine, or 0.04% paraquat and 0.49% atrazine.

Table 1. (Continued)

Active ingredient	Trade name	Type	Formulation	Use	Criteria for restricted use
TEPP		insecticide	all formulations	all uses	acute dermal and inhalation toxicity, residue effects on birds and mammals
zinc phosphide		rodenticide	dry formulations 60% or greater	all uses	acute oral and inhalation toxicity, effects on nontarget organisms
zinc phosphide		rodenticide	all bait formulations	all nondomestic outdoor uses (other than around buildings)	acute oral and inhalation toxicity, effects on nontarget organisms
zinc phosphide		rodenticide	dry formulations 10% or greater	domestic uses	acute oral and inhalation toxicity, effects on nontarget organisms
ziram	Milbam	fungicide	all formulations	all uses	conditional registration

Table 2. Illinois State-Labeled Pesticides 24(c)'s as of November, 1982

Product	Company	Site	Target	Expiration date
Aatrex 80W, or with Princep as tank mix	Ciba-Geigy	tree seedlings	weeds	3/14/84
Abate Corncob Granular	Macon County Mosquito Abatement	rivers, flood plains, pools	mosquito larvae	3/13/84
Atroban 10% Ear Tags (permethrin)	Burroughs-Wellcome	cattle	face and horn flies	10/1/86
Atroban 25% WP (permethrin)	Burroughs-Wellcome	livestock premises	barn flies	10/1/86
Basagran	BASF Wyandotte	soybeans	weeds	6/11/83
Benlate	DuPont	peach trees	canker	4/1/86
Bexton 4L Flowable	Dow	corn	multiflora rose	3/23/84
Bexton 31.7% + Atrazine 10.6%	Dow	corn, grain sorghum	weeds	2/1/85
Bexton 4L + Bladex 80W or 4L	Dow	corn	preemergence for weeds	3/23/84
Bladex 4L and 80W	Shell	field corn	grasses, broadleaf weeds	1/1/86
Bladex 4L + Atrazine 4L + Dual 8E	Shell	corn	grasses, broadleaf weeds	1/1/86
Bladex 80W + Atrazine 80W + Dual 8E	Shell	corn	grasses, broadleaf weeds	1/1/86
Citcop 6E Tank Mix	Cities Service	tomatoes	bacterial spot, early blight, septoria	11/26/84
Citcop-Bravo, Citcop 4E	Cities Service	tomatoes	bacterial spot, early blight, septoria	8/3/83
Contrax P	Motomco Ltd.	orchards, groves	meadow and pine mice (voles)	8/17/87
Counter 15G	American Cyanamid	field corn	lesion nematodes	4/27/84
Cygon 400	American Cyanamid	soybeans, wheat, roadsides, alfalfa, field corn, sorghum	grasshoppers	8/18/83

Table 2. (Continued)

Product	Company	Site	Target	Expiration date
Daconil 2787 Flowable	Diamond-Shamrock	turf	anthracnose	3/23/84
Dow General Weed Killer	Dow	onion sets	To desiccate tops	4/17/83
Ecopro 1707F temephos 7.2%	Environmental Chemicals	catch basins	mosquito larvae	3/1/85
Ectiban EC and 25% WP (permethrin)	ICI Americas	feedlots, stables, poultry houses, swine houses, beef cattle houses, dairy barns	house flies, stable flies, other manure-breeding flies	7/1/85
Eradicane 6.7E	Stauffer	corn	wild proso millet	1/1/87
Furadan 4F	FMC	no-till alfalfa seedings	crickets, grasshoppers, potato leafhoppers, pillbugs	1/4/83
Furadan 10G	FMC	sweet corn	flea beetles, rootworms, nematodes	9/8/87
Furadan 10G	FMC	squash, cucumbers, melons, pumpkins	nematodes, striped and spotted cucumber beetles	7/12/87
Furadan 10G	Mobay	cucurbits (squash, cucumbers, melons, pumpkins)	nematodes, striped and spotted cucumber beetles	7/12/87
Gardstar 10% Ear Tags (permethrin)	Y-Tex	cattle	face and horn flies	9/30/86
Gramoxone Paraquat	ICI Americas	no-till sunflowers	weeds	6/30/87
Hard Hitter 5.7% EC, and 25% WP (permethrin)	Ralston Purina	poultry and livestock premises	horse, stable, and other flies	3/15/86
Hinder 15% Ammonium Soaps	Thompson-Hayward	fruit trees, vines, vegetables, field crops, ornamentals, nursery, noncrop areas	deer and rabbit repellent	7/31/84
Hopkins Zinc Phosphide 2% Bait	Hopkins	no-till corn	prairie and meadow voles	8/17/85
Insectaban 10	Moorman	livestock premises	house and stable flies	7/30/86

Table 2. (Continued)

Product	Company	Site	Target	Expiration date
Insectrin 5.7% EC (permethrin)	Hess & Clark	poultry and livestock premises	house, stable, and other flies	3/13/86
Insectrin 25% WP (permethrin)	Hess & Clark	poultry and livestock premises	house, stable, and other flies	3/15/86
Lasso, Lasso + Atrazine	Monsanto	seed corn production	lay-by postemergence corn treatment	4/27/83
Lindane EC #20 Professional	Dettlebach	structures	wood-infesting beetles	3/15/83
Lorsban 4E	Dow	corn	cutworms	2/7/83
Manzate D	DuPont	beans	rust	4/27/84
Manzate 200F	DuPont	ornamentals, flowers	diseases	4/27/83
Mertect 340-F Thiabendazole	Merck	soybeans for seed	pod and stem blight, anthracnose, brown spot, frog-eye leaf spot	9/3/87
Mesurol 50% Hopper-Box Treatment	Mobay	corn seed	small rodents, blackbirds	3/15/84
Mycoshield Terramycin	Pfizer, Inc.	toronto creeping bentgrass	bacterial wilt	5/18/87
Nemacur 3	Mobay	nonbearing fruit trees	lesion and dagger nematodes	2/1/87
Orthene 15.6% EC and 9.4% EC	Chevron	honeysuckle	aphids	6/14/87
Ortho Methoxychlor 2E	Chevron	stored grains, field corn seed	stored grain insects	3/14/84
Ortho Paraquat CL	Chevron	no-till sunflowers	weeds	6/30/87
Overtime 10% EC Bioceutic (permethrin)	Phillips Roxane	barn and premises	house, stable, false stable, and face flies	3/1/86
Penncap-M	Pennwalt	corn	corn borer, adult corn rootworms	8/1/83
Permectrin 10% EC (permethrin)	Phillips Roxane	barn and premises	house, stable, false stable, and face flies	3/1/86

Table 2. (Continued)

Product	Company	Site	Target	Expiration date
Pirimor 50W	ICI Americas	chrysanthemums and ornamentals in greenhouses, field potatoes	greenbugs	8/1/85
Pramex 13.3% E.C.	Penick	chrysanthemums in greenhouses and slathouses	leaf miners	1/7/85
Premerge 3	Dow	peas	root rot	1/16/83
Premerge 3	Vertac	peas	root rot	9/24/87
Princep 4G	Ciba-Geigy	tree seedlings	weeds	3/25/86
Princep 80W	Ciba-Geigy	tree seedlings	weeds	3/14/84
Ramrod 42.2% Flowable	Monsanto	corn, grain sorghum, processing green peas	annual grasses, certain broadleaf weeds	11/26/84
Ramrod 31.5% + Atrazine 10.5% Flowable	Monsanto	corn, grain sorghum	annual grasses, certain broadleaf weeds	11/26/84
Sevimol 4	Union Carbide	corn	chinch bugs	4/11/84
Sevin 4-Oil	Union Carbide	soybeans	grasshoppers, green cloverworms	8/3/83
Sevin 80S	Union Carbide	corn	chinch bugs	4/11/84
Sevin 50W	Union Carbide	corn	chinch bugs	4/6/84
Temik 10G	Union Carbide	greenhouse ornamentals	insects, mites, nematodes	2/1/85
Temik 15G	Union Carbide	soybeans	nematodes	4/9/87
Terrachlor 10%G and 75% WP	Olin	lawn and turf	snow mold	8/1/85
Tolban 4E	Ciba-Geigy	field peas	annual grasses, broadleaf weeds	2/15/86
Tordon 10K Pellets	Dow	permanent grass pasture and range land	multiflora rose	4/9/84
Turfcide 10G	Olin	lawn and turf	snow mold	8/1/85
Vertac General Weed Killer	Vertac	onions for sets	desiccant	9/24/87

Table 2. (Continued)

Product	Company	Site	Target	Expiration date
Vitavax-250B	Uniroyal	barley, oats, wheat	loose and covered smut	8/31/83
Vydate L	DuPont	apples	european red mite, two-spotted spider mites, white apple leafhoppers	7/1/85

An Update on the Special Review, 1982 (Previously RPAR)

C.W. MacMonegle, C.E. Colwell, and D.R. Pike

The Rebuttable Presumption against Registration (RPAR) has been under way for several years. A number of pesticides that are commonly used in Illinois have been or are involved in these proceedings. Several others may be reviewed in the future.

For a pesticide to be reviewed by RPAR, it must in the judgment of the U.S. Environmental Protection Agency (EPA) meet or exceed these risk criteria or "triggers":

1. Acute toxicity
2. Chronic toxicity
   a. Oncogenic
   b. Mutagenic
3. Other chronic effects, that is, reproductive, spermatogenic, testiculate
4. Significant reduction of wildlife, endangered species, and nontarget species
5. Lack of emergency treatment or antidote

Several general categories have been delineated for a pesticide undergoing RPAR review. These categories indicate the current status of the review process for any particular pesticide. Initially, a pesticide is placed in the pre-RPAR category. During this stage the EPA conducts an in-depth literature search of all scientific studies concerning the RPAR triggers of a pesticide. If the triggers appear to be valid, the EPA will then analyze the potential of exposure to the pesticide and determine its potential risk position. If its potential risk seems great enough, the pesticide is issued a Notice of Presumption against Registration.

With the issuance of an RPAR, the formal public review process begins. During a certain defined period, evidence rebutting the risks may be submitted by interested parties. The information is gathered in the form of rebuttable comments, additional information on risk, and input from other agencies (that is, the U.S. Department of Agriculture).

If the triggers are successfully rebutted, the pesticide is returned to registration. If the rebuttal is not successful, the EPA determines the relative risks and benefits of the pesticide based on previous analyses, and issues a statement of the pesticide's regulatory status. This document includes information on the risk that currently registered uses of the pesticide may create, an analysis of the beneficial effects of the pesticide on production practices and quality, an evaluation of the relative benefits and risks of each of the regulatory options, and the recommended regulatory position. The EPA may recommend either cancellation of all or some uses of the product, restriction of some or all uses, or return of the pesticide to its existing registration.

The following tables list all pesticides that have been or are involved in the RPAR and pre-RPAR processes and indicate their status within the proceedings. There were no new RPAR chemicals in 1982.

Table 1. Pre-RPAR Chemicals

Chemical	Trigger	Status
dichlorvos (DDVP)	Chronic toxicity	Evaluation ongoing as degraded to DDVP
methanearsonates	Chronic toxicity	Additional data requested
Naled (as degrades to DDVP)	Cronic toxicity	See dichlorvos
ronnel	Chronic toxicity	Schedule being developed
trichlorofon	Chronic toxicity Reproductive effects	Evaluation ongoing

Table 2. RPAR Chemicals

Chemicals	Date of RPAR issue	Current status
Benomyl	12/6/78	Undergoing study
Cadmium	10/27/77	Undergoing study
Captan	8/18/80	Undergoing study
Carbon tetrachloride	10/15/80	Undergoing study
Chloroform	4/6/76	Undergoing study
Coal tar	10/18/78	Undergoing study
Creosote	10/18/78	See coal tar
EBDC's	8/10/77	Rebuttal comments being reviewed
EPN	9/19/79	Rebuttal comments being reviewed
EDB	12/14/77	In agency review
Ethylene oxide	1/78	Undergoing study
Inorganic arsenicals	10/18/78	Undergoing study
Lindane	2/17/77	Undergoing study
Malic hydrazide	10/28/77	Undergoing study
PCNB	10/13/77	Undergoing study
PCP	10/18/78	Undergoing study
Sodium fluoroacetate/1080	12/1/76	In agency review

Table 2. RPAR Chemicals (continued)

Chemicals	Date of RPAR issue	Current status
Strychnine/strychnine sulfate	12/1/76	Undergoing study
Thiophanate methyl	12/1/78	See Benomyl
Toxaphene	5/25/77	Rebuttal comments being reviewed
2,4,5 Trichlorophenal	8/28/78	Some formulations cancelled, reformulations being processed

Table 3. Final Actions by the U.S. EPA

Voluntary cancellations	Intent to cancel or suspend	Intent to register	RPAR completed
Acrylonitrile	Aldrin/Dieldrin	cacodylic acid	Amitraz
Aramite	chlordane/heptachlor	carbaryl	Chlorobenzilate
Arsenic trioxide	Chlordecone	Diflubenzuron	DBCP
Benzene	DBCP	maleic hydrazide	diallate
BHC	DDD	10, 10' Oxybisphanoxarsine	dimethoate
Chloranil	DDT	paraquat	Endrin
Chlordecone	Endrin	piperonyl butoxide	GOAL
Copper acetoarsenite	Mirex	rotenone	PCNB
Basic copper arsenate	2,4,5-T/Silvex	terbutryn	Pronamide
Ebon		Triallate	1081
Isocyanurates		S,S,S-tributyl phosphorotrithioate	2,4,5-T/Silvex
Monuron			trifluralin
OMPA			
Perthane			
Phenarazine chloride			
Safrole			
Sodium arsenite			
Strobane			
Trysben			

Reducing Bird Damage in Illinois

R.D. Ogden

Damage caused by birds is widespread and serious in the central and southern parts of Illinois. The nation's winter population of blackbirds, starlings, grackles, and cowbirds is conservatively estimated at 500 million. Bird damage in Illinois occurs where human use of land is intensive and agricultural foods are available and when certain species of birds congregate following the breeding season, during migration, and in the winter. Extensive fields of agricultural crops near roosts provide attractive and often preferred feed for crop-consuming birds such as blackbirds and starlings. Problems result when the birds radiate out from their roosts into fields of unharvested crops or to livestock feedlots. Whether or not problems occur depends upon many factors including weather conditions, soil moisture, location of feed, time of harvest, and the extent and effectiveness of bird damage control by landowners.

Bird problems are concentrated in local areas determined by the distance the birds fly from roosts to feed in crop fields. This distance is commonly up to 20 or 25 miles, but is rarely more than 40 miles; most problems occur within the first 10 miles from roosts. Within this feeding radius, but especially along local flight corridors, flocks of birds may find a particularly attractive field or feedlot, where they will feed repeatedly if left undisturbed or only slightly disturbed. Birds adapt to local food conditions primarily by shortening or extending their daily feeding radius or by moving to different sites to obtain food within a local feeding zone. These behavioral characteristics of birds must be considered when designing control programs for local bird problems. Estimates of the economic impact of birds on agricultural crops in the United States are as high as $100 million annually.

There is no single answer to the bird problem. Even in a specific bird damage situation, a combination of controls is often better than the exclusive use of any one technique. Perhaps desirable for some species, population reductions should not be looked on as the ultimate answer to most bird damage problems. At present there is no economically feasible method to effectively reduce bird populations over wide areas. Because most birds involved are migratory, local population control is equally difficult. Most species of birds have relatively large broods and are capable of two or more successful nestings per year. Even if extreme population reduction were attempted, it would probably be only a short-term solution. To be effective, population control techniques should usually be augmented with other nonlethal control measures.

The best solution to a bird problem will usually involve an integrated approach that includes several control techniques. Control programs that rely exclusively on the use of one method are usually doomed to failure. It is important that a program be planned with a thorough understanding of both the biology of the birds and the advantages and limitations of the various control techniques. This report is intended to provide the reader with a basic understanding of the biology of those birds usually associated with damage, the types of damage control techniques available, and suggestions for dealing with bird damage situations in Illinois.

Problem Birds and Their Biology

Starling

Although there are about 110 species of starlings in the world, only one, the European starling *(Sturnus vulgaris)*, is found in North America. Starlings are often mistaken for blackbirds. It is important to be able to recognize different bird species because some types of bird control are more specific for certain species than for others. Adult starlings are more or less black in color, although during the winter the starling's breast is speckled with white check marks. As spring approaches, these marks wear off, leaving the breast more or less a glossy black. The bill is black during part of the year, but turns yellow during the breeding season (January through June). Distinguishing features of the starling include its relatively short tail and short, triangular wings. It flies swiftly and directly and does not undulate up and down in flight as most blackbirds do. Sometimes its flight is a series of glides interspersed with rapid wingbeats.

Starlings, which are year-round residents in Illinois, are communal, living together in smaller flocks of up to several hundred birds during the warmer months. They often nest in colonies and can have one or two broods of four or five young each year. Starlings are not truly migratory, but with the onset of colder months they band their summer flocks together to form huge flocks, and seek a suitable location for their winter roost. These flocks move south as winter conditions and available food dictate. At sunrise the starlings leave their roosts and travel 15 to 30 miles in smaller flocks to their selected feeding and loafing areas. As evening approaches, they return to their favored roosting area, usually in dense pine tree plantations, barns or cattle sheds around rural farmsteads, trees in small towns or suburban areas, and occasionally in or on buildings in downtown urban areas.

Blackbird

The birds most properly associated with this group in Illinois are the red-winged blackbird *(Agelaius phoeniceus)*, the Brewer's blackbird *(Euphagus cyanocephalus)*, and the rusty blackbird *(Euphagus carolinus)*. With habits similar to those of blackbirds, the common grackle and the brown-headed cowbird are often found in mixed flocks of blackbirds. The breeding population is estimated at about 400 million in this country. Rusty and Brewer's blackbirds, similar in size to red-wings, are completely black and difficult to distinguish from each other. The black adult male red-wings with their scarlet shoulders are familiar and unmistakable, but the brown, sparrow-like females and immature males with their streaked breasts often go unrecognized. Red-winged blackbirds are migratory and are not commonly present in northern and central Illinois during winter months. They do, however, nest throughout the state, most commonly in marshland, hayfields, unused pasture, and other abandoned or unused fields. The nests are usually in shrubs or sturdy herbs, sometimes in saplings, but rarely in big trees. Red-wings commonly have two broods of four young per year. The rusty blackbird and Brewer's blackbird migrate through Illinois in the fall and spring, but they generally nest farther north than Illinois. They are, however, sometimes present locally in the winter.

During the nesting season, when the birds are widely scattered, blackbirds feed extensively on grubs, on caterpillars such as armyworms, cutworms, and corn earworms, and on beetles and other insects. During the milk and dough stages, red-wings feed heavily on ripening grain, and then on small grains such as milo and millet until harvest.

Blackbirds make daily trips from their roosts to grain fields. About dawn the red-wings depart in different lines of flight. Some descend upon the first acceptable grain field, some drop out at various intervals along the way, and others continue in beeline flight to destinations perhaps as far as 20 miles from the roost.

By the end of July instead of returning nightly to their breeding areas, groups of red-wings will roost in or near marshlands. By August newcomers from nearby breeding grounds and migrants from more distant areas increase the size of the flocks. These flocks may also be joined by grackles, cowbirds, and starlings.

Common Grackle

Common grackles *(Quiscalus quiscula)* are robin-sized or larger, with long, keel-shaped tails. Adults are an iridescent, glossy black with a purple or bronze cast. Young grackles recently out of the nest are a plain rich brown, but they gradually develop shiny black feathers during the summer. Common grackles are migratory and are seldom found in northern and central Illinois during the winter. They are abundant in the state during spring and fall and are also common nesters throughout Illinois. Grackles nest in colonies in evergreen shrubs and trees, dense woodlots, thickets, hedgerows, and viny tangles, and usually have only one brood of five young per year.

Unlike red-wings, which search marshes and hayfields near their nests, grackles often range quite far in search of food, frequently traveling to fields being plowed or cultivated. After small grain is harvested in late June and early July, when grackles are through nesting, they feed extensively on waste grain in stubble. By the end of July grackles have left their specific breeding areas to roost either in trees or marshes, often joining flocks of blackbirds and starlings. After leaving the roost, grackles do not usually form into groups as small as those of blackbirds, but instead tend to remain in large marauding bands throughout the day, attacking one grain field after another.

Brown-Headed Cowbird

Cowbirds *(Molothrus ater)* are smaller than red-winged blackbirds and have much heavier beaks. Adult males are a glossy black with dark brown heads; females are plain gray with pale throats. Brown-headed cowbirds are migratory. They are uncommon in northern and central Illinois during winter, but are abundant throughout the state from spring through fall. Cowbirds do not incubate their own eggs, depositing them instead in the nests of many other species found in Illinois. Cowbirds lay one or two eggs per host nest from April through July. Having been raised to maturity by foster parents, the young cowbirds join in flocks with other cowbirds. Cowbirds are often associated with flocks of blackbirds, which have similar flocking habits.

House Sparrow

The house sparrow *(Passer domesticus)* was introduced into this country from Europe in the middle 1800's. These rather small, brown birds are usually found near human habitation and are familiar to most people. The male is recognized by his black bib and bill and white cheeks. The female, often confused with other sparrows, has an unstreaked, dingy breast and a streaked back. House sparrows are nonmigratory and are abundant, permanent residents in Illinois. Capable of producing several broods of four young per year, they are highly gregarious and often form into flocks. They prefer to nest in or around buildings and are very difficult to get rid of once established. Although their food consists primarily of seeds and insects, sparrows can cause serious damage to fruit or ripening grain. Probably a more serious problem is the filth caused by their droppings and bulky nests.

Pigeon

Pigeons *(Columba livia)* similar to those now living in a semiwild state in towns and cities have been closely associated with man since before recorded history. Originally, these birds probably came from the blue rock or common pigeon of Europe, Asia, and Africa. Pigeons use man-made structures such as barns, city buildings, bridges, and overpasses almost exclusively for their roosting and nesting sites. Pigeons are nonmigratory and are common throughout Illinois wherever suitable nesting and roosting areas are available. They lay two eggs per nesting, mainly from January through June, but a few may be laid in any month. As scavengers for grain and seeds, pigeons may feed in or near stubble fields, feedlots, grain elevators, and the like. Pigeons owned by individuals can generally be recognized by numbered bands on their legs. Excessive numbers of pigeons can cause property damage and may constitute a health hazard.

Crow

The crow *(Corvus brachyrhynchos)*, a large, black bird with a heavy bill, is generally well known and easily recognized. Common in Illinois, crows lay about four eggs some time between mid-March and the end of May. Crows are somewhat migratory, but do not winter as far south as do most birds. In winter the number of crows in Illinois may increase because of an influx of birds from the northern states or Canada. Plant material comprises about two-thirds of the crow's diet. Although wheat is their most important food on a year-round basis, they apparently do not cause serious damage to this crop. Grain sorghum and corn may be damaged in local situations; cherries, watermelons, and other fruits can also be seriously damaged. On rare occasions crows may attack weak, sick, or injured lambs, pigs, or calves. Crows perform a valuable, sanitary function by consuming carrion.

Techniques for Controlling Bird Damage

Methods for alleviating bird damage generally fall into three broad categories: biological, mechanical, and chemical.

Biological Controls

Decoy crops and cultural practices. Sometimes it is economical to plant a less valuable crop, one that is more attractive to depredating birds, adjacent to valuable crops to divert the birds. Often techniques such as planting or harvesting early or late, changing crop types, leaving stubble fields standing, and planting all grain in an area at the same time can reduce serious bird damage to field crops.

Habitat manipulation. Most commonly used for roosting problems, this technique consists of thinning or removing roosting cover or eliminating access to roosting or nesting sites in or around buildings and other structures.

Bird-resistant varieties. Some progress has been made in developing bird-resistant crop varieties. The use of these varieties, especially grain sorghum, may prove to be a promising means of combating losses to birds in the future.

In general, because most biological methods are costly or impractical, they have not been widely accepted by agriculturalists. When applicable, however, these methods have effectively reduced bird damage.

Mechanical Controls

Mechanical control methods, consisting primarily of scaring devices, are widely used and often are effective in the control of birds in grain fields and in urban areas. Frightening devices include propane or acetylene exploders, shellcrackers, fireworks, windmills, scarecrows, and hawk or owl models. Recorded alarm or distress calls of birds broadcast through mobile or stationary units or played on record players are also effective. Other types of mechanical controls include netting, "porcupine wires," and sticky compounds used to discourage birds from roosting in or on buildings. Frightening devices are discussed in greater detail later in this report. Decoy traps have been used effectively in Illinois and elsewhere to remove small populations of birds, especially in feedlots, orchards, and berry plantings.

Chemical Controls

The chemical approach to reducing bird damage to agricultural crops is promising. Most major research efforts have been concentrated in this area. Chemicals applied for control of birds must be species selective, effective, economically practical, and environmentally safe. Types of chemicals for managing bird problems include repellents, stressing agents, toxicants, chemosterilants, and frightening agents. The use of poisons (toxicants) for bird control in Illinois is restricted to nonprotected species or to use by trained governmental agents. Refer questions about the legality of a planned bird control program to the Illinois Department of Conservation or to the U.S. Fish and Wildlife Service (ADC), both located in Springfield, Illinois.

Repellents. The most promising repellent compound found to date is methiocarb, which has been shown to be effective in protecting newly planted corn from blackbirds, crows, and pheasants. Registered for use in Illinois as a seed treatment, methiocarb has also shown promise as a protectant for ripening sunflowers and grain sorghum and in controlling bird damage to fruit. After further testing, it is hoped that this product will become more widely available for use in controlling bird damage to crops.

Frightening agents. One of the most useful chemicals for reducing bird damage to agricultural crops is the chemical frightening agent Avitrol®. This chemical is considered a frightening agent because most birds that ingest treated bait react by emitting distress cries while flying erratically. This behavior frightens other members of the flock from the area. Avitrol is relatively effective at low use levels and is relatively safe, killing less than one percent of the flock. It is effective in reducing bird damage to field corn and sweet corn, and initial studies on sorghum, although inconclusive, are promising. Avitrol can be mixed on many types of grain baits and has been shown to be an effective control in feedlots and other areas, in addition to grain fields. Avitrol can only be used by licensed Pest Control Operators or government personnel trained in bird control.

Stressing agents. Stressing agents are essentially detergents or wetting agents that lower the surface tension of water and enhance the wetting of a bird's feathers. The bird-stressing agent PA-14 is registered for use by qualified United States Fish and Wildlife Service personnel or by those under their direct supervision. Before application can be made, a feasibility study must be conducted and alternative dispersal methods explored. If the use of this compound is approved, then the material is sprayed on large roosting concentrations of starlings or blackbirds immediately before or during cold, wet weather. Death occurs when the bird's feathers become wet enough that they lose their insulating effect, thus causing excessive loss of body heat. The chill factor must be near 42°F, and at least a half inch of rain should fall during or immediately after treatment. This chemical is poisonous to fish and, to some degree, plants. Spraying tree roosts should be confined to the period when trees are dormant. Use of this chemical is recommended only in cases of extremely large and serious bird problems where other techniques will not work.

Toxicants. The development of toxic agents or poisons has been directed primarily at starlings. Starlicide® is a pelleted toxic bait registered for use in cattle feedlots and poultry-raising operations. The treated pellets, diluted with untreated pellets at a 1:10 ratio, are scattered thinly in empty pens and alleyways or in troughs placed above feeding bunks. Available only in the pelleted form, Starlicide may not be effective unless mixed with materials the starlings are feeding on. Starlicide is a slow-acting poison highly toxic to starlings and blackbirds, but is generally less toxic to most other birds. The safety of the compound can be increased by careful consideration of bait material and placement, dilution rates, and timing. Its effectiveness is probably related to its slow action. It takes up to 48 hours for birds to die after they ingest a lethal dose, and they do not show bait aversion. About 40 percent of the dead birds will be found at the nighttime roost rather than at the bait site. Strychnine-treated grain (0.6 percent) is sometimes used for the control of sparrows and pigeons, but its use is not generally recommended because of the hazard to other species. After using any toxicant, dead birds should be picked up and properly disposed of whenever possible.

Poison perches. Poison perches are useful for killing birds inside or on buildings when it is impossible to exclude them by other means. These perches, consisting of a small metal tube with an exposed wick, vary from a few inches to several feet in length, with different sizes to fit the feet of the target birds.. The cloth wick inside this tube is soaked with a contact poison; birds perching on the tube absorb the poison through their feet and are killed. Because of its low toxicity to other animals, Fenthion is most desirable for use in these perches. Endrin can also be used, but it is highly toxic to other animals. *Extreme care should be practiced in the use of contact poisons.* These chemicals should be used only by a licensed Pest Control Operator, and perches should not be near feeding operations or food storaged areas.

Chemosterilants. The only registered chemosterilant for birds is Ornitrol®, which is used on wild pigeons. Although this form of "birth control" for pigeons works, it has several disadvantages. The success of the technique requires that the treated bait be eaten in a sufficient quantity for several days before it is effective. This chemical is capable of inhibiting reproduction for up to six months and must be used once or twice each year to ensure population supression. Research is being conducted in an attempt to develop a chemosterilant for reducing damage by blackbirds.

Bird Problems and Solutions

Protecting Grain Fields

Damage to ripening grain can be avoided or reduced by modifying the crop culture, frightening birds from fields, or both.

Cultural methods. Grain plantings should be scheduled so that most of the grain in a general area enters the vulnerable stage at the same time. The number of birds in many grain producing areas increases as the season progresses; thus, late grain may be subject to the heaviest attack, whereas early grain is less damaged. Bird damage is usually greatest in fields or parts of fields close to a body of water, marshland, desirable resting cover, or a regularly used flightline. In this type of situation a decision to grow a crop not usually subject to severe bird attack may be in order. Sometimes grain damage can be reduced by removing loafing or roosting cover adjacent to grain fields. Stubble fields left standing until the bird danger is past will provide the birds with alternate feeding sites, resulting in decreased damage to unharvested crops.

Certain varieties of grain show some resistance to blackbird attack. Even when an attack is heavy, sorghum growers can usually obtain appreciable relief from crop damage if they use protection methods properly.

Frightening devices. Gas exploders, .22 caliber rifles, rope firecrackers, shell-crackers, airplanes, shotguns, and recorded blackbird alarm cries are used to scare blackbirds from grain fields. Frightening blackbirds from a field will not necessarily correct the problem. If other acceptable seed foods occur nearby, blackbirds will feed on them.

For best results from frightening devices, the following procedures are recommended:

(1) Bird scaring should begin when grain is first susceptible to damage or at least at the earliest indication that blackbirds are feeding on grain.

(2) During the damage season, corn protection measures should be used throughout the day, particularly in the early morning when blackbirds first appear, and again during the late afternoon feeding period. Extra protection is also required during rainy or foggy weather. Birds should not be allowed to remain in a field, since they serve as decoys attracting others. If blackbirds are permitted to settle down, they often stay in the vicinity for the day.

(3) A combination of bird-scaring techniques should be used whenever possible, particularly at times when bird pressure is high, such as in early morning, in late afternoon, and during bad weather. Although farmers can usually reduce blackbird damage to grain by using one scaring device correctly, crop protection can be most effective when several scaring techniques are used. The relative costs and benefits of increased protective measures should be carefully evaluated, however, before using additional techniques.

(4) For maximum benefit, the scaring devices, especially the stationary ones such as gas exploders and rope firecrackers, should be moved frequently (twice daily) in a grain field.

The automatic gas exploder, probably the principal bird frightening device, usually reduces grain damage. Gas exploders produce loud explosions at automatically timed intervals when a spark or pilot flame ignites the propane, butane, or acetylene gas. Some exploder models have unique modifications, such as automatic starting and stopping switches controlled by timing or light-sensing mechanisms, an apparatus for partly rotating the exploder after each firing so that the sound carries in a different direction, and a means of mounting the exploder on a vehicle with a detonating switch in the cab.

Exploders mounted on platforms and operated above the height of the corn give best results. Some farmers have excellent results by mounting an exploder on the roof of a pick-up truck in addition to using stationary units in the field. A woods margin or buildings may help direct or intensify the sound. The effective range of an exploder varies. Tests show that grain damage can be cut in half within 600 feet of an exploder (equivalent to 26 acres of protection), but as a general rule with moderate bird pressure, one exploder should be used for every 10 acres of grain.

The .22 caliber rifle is an effective bird-scaring device, but should be used only where it is legal and safe. One rifleman from a high position such as a rooftop, silo, or tall platform can protect as much as 100 acres. As birds settle into a field, a bullet is fired earthward into their midst.

Flash-salute-type firecrackers, popularly known as bulldogs, cannon crackers, cherry bombs, or salutes, are used in rope firecrackers. Firecracker fuses are inserted at intervals between strands of a loosely twisted, cotton rope, one end of which is tied to the apex of a tripod of wooden stakes. The free end of the rope is ignited and as it burns, the ignited firecrackers drop from the rope and explode. Approximately 10 acres of standing grain can be protected with one rope firecracker assembly. A 55-gallon barrel with the rope suspended inside amplifies the sound and reduces the fire hazard. Fireworks are prohibited in many areas. Consult local laws before using fireworks in bird control.

A shotgun firing either regular ammunition or shellcrackers is an effective bird-scaring tool. Shellcrackers are special shotgun shells that discharge a projectile that explodes after traveling about 100 yards. Shotgun shells and shellcrackers may be used to supplement automatic devices or used alone, especially in early morning and late afternoon. Shellcrackers should not be fired over or into dry vegetation or other potentially flammable materials. The occasional killing of a bird with regular shotgun shells can increase the effectiveness of shellcrackers and other scare devices. Shooting is much more effective when a vehicle is used to get within range of birds quickly.

Light airplanes, sometimes equipped with sirens or horns and flown slightly above tassel height, are used in some areas to frighten birds. Pilots often try to cover a grain field systematically, because the birds frequently drop farther down into the grain rather than flushing when the plane approaches. Airplane operations, restricted to times when flying conditions are favorable, are expensive and the results inconsistent. Federal law prohibits shooting or harassing any wildlife from aircraft without an appropriate state permit.

Broadcasting recorded alarm and distress calls of birds has been found effective in small corn acreages. This method is not commonly used, however, because of the expense of the equipment involved.

<u>Chemical frightening agents</u>. The use of Avitrol has been demonstrated to be of value in protecting field corn, sunflowers, and sweet corn from damage by blackbirds. When treating fields, do not place the bait nearer than 40 to 50 feet to the edge, because nontarget birds use the outer perimeter heavily. Avitrol is registered for use in protecting corn but not for grain sorghum. Preliminary tests using this chemical have not shown as much promise for reducing bird damage to grain sorghum, particularly where large numbers of brown-headed cowbirds are involved. Cowbirds do not respond as well to the Avitrol baits as do some blackbirds. Use of Avitrol is restricted to Pest Control Operators or government personnel trained in bird damage control. Several aerial applicators have been certified in Illinois to apply Avitrol to cornfields.

Other methods. In areas where other control techniques are not legal or practical, visual deterrents can offer some protection. These methods include twirlers, windmills, scarecrows, twine strung over the grain, and reflecting plates. Small plots can be protected by covering the grain with netting or by putting paper cups or bags on individual ears after pollination.

Population reduction. Blackbirds are protected by Illinois state law. They can be killed when committing or about to commit serious damage to agricultural crops only after a permit has been received from the Illinois Department of Conservation. Such operations must be conducted in conformity with state law, so check with the Illinois Department of Conservation before initiating lethal bird control activities. There is no feasible method at present for appreciably reducing most populations of grain-depredating birds during the damage period in late summer and early fall. Shooting is widely practiced, but it is more effective as a scaring technique. The large decoy trap, which has been moderately successful in certain fruit-growing areas, has not been successful as a means of alleviating grain damage because so many traps are needed. No completely satisfactory chemicals have been developed either as repellents, lethal baits, or contact poisons for use in ripening grain fields or roosting areas. These problems are compounded by the fact that most of the problem species are migratory and have a high reproductive capacity.

Bird Roosts

Urban roosts. Urban roosts pose a number of problems to residents of cities, suburbs, or towns. Excrement and feathers from roosting birds contaminate sidewalks, cars, and outdoor furniture. Occasionally birds die and their carcasses add to the insanitary conditions. The sheer volume of noise made by large flocks of birds is also annoying to many people. Collections of droppings under bird roosts create ideal conditions for the growth of the histoplasmosis fungus, which can cause a respiratory disease in humans. Birds most commonly associated with urban roosts are starlings, although some grackles, red-wings, and robins are often present. Usually the roosting flocks begin to build up in late summer, following the end of the nesting season. Most birds will leave the roost as winter approaches, but starlings may remain throughout the winter if adequate sources of food are available within a 20- or 30-mile radius.

In general, fireworks, shotguns, propane exploders, and other noise-making devices cannot be used in an urban situation without obtaining special permits. Broadcast-amplified recordings of the distress calls of starlings and other birds are usually the most practical alternative. These recordings are most effective if begun before the birds have become well established at the roost. Begin playing the recordings near sundown as soon as a significant number of birds have arrived at the roost. The sound is most effective if it is directed at the birds and is not obstructed by buildings, trees, and the like. For greatest effect, the sound should be broadcast from one or more mobile units or from several stationary units. If a large area of a town or city is concerned, broadcasting alarm calls over a local radio station and having residents play their radios out the windows can be successful. Another alternative is to distribute recordings to a number of residents in the affected area. Generally, there will be no noticeable reduction in the number of birds for the first several nights, but usually by the fourth or fifth night most of the birds should have left. Distress calls are sometimes more effective if birdshot or shellcrackers are periodically fired into the flocks. Persistence is the key to dispersing roosts with distress calls.

Rural roosts. Starlings, blackbirds, and grackles sometimes cause problems in rural areas by roosting in woodlots or pine plantations. In general, the alarm call techniques described for urban roosts also work for rural roosts. In a rural situation, however, it is usually possible to use other types of frightening devices, including fireworks, propane exploders, and shellcrackers. These techniques should be used near sunset when the birds are returning to the roost. Using poison baits to control bird numbers at roosts is difficult unless the feeding area is known. Wetting agents can sometimes be effective in a severe bird roosting situation, but weather conditions must be nearly perfect before they are successful. These chemicals can only be used by or under the supervision of government personnel trained in bird control and are not generally recommended. The main difficulty of any bird problem is the tremendous numbers that are involved. Even a population reduction of tens of thousands of birds may be only a small portion of the total population in an area. Large clutches of eggs and repeated nestings enable many pest birds to compensate rapidly for population reductions.

Roosts in and on buildings. House sparrows, pigeons, and starlings are the most common birds creating roosting problems in buildings. They may get into machine sheds, barns, garages, and so forth, either to nest or to roost. The best and most permanent solution to this type of problem is, of course, to deny the birds access to the building or to roosting or nesting sites within the building. Doors should be tight-fitting and should be kept closed; windows should be closed or covered with quarter-inch or smaller wire mesh.

If it is impossible to exclude birds from the interior of the building, it is sometimes possible to screen off rafters and other preferred nesting and roosting areas with quarter-inch hardware cloth. Sticky or irritating compounds can be applied to roosts and will sometimes discourage the birds from using them. Perches poisoned with Fenthion or endrin can be used, but ways to keep birds from getting in should also be used. Revolving lights and ultrasonic sounds have had varying results in repelling birds from buildings and warehouses. Homeowners can usually control individual starlings by live-trapping them with a nest-box trap or other type of live trap. Sparrows and pigeons can be discouraged from nesting in buildings by destroying their nests and eggs at two-week intervals during the spring and summer months. Use a hook fastened to the end of a long pole to tear down nests in rafters or under eaves. If at all possible, block off nesting sites after the nests have been destroyed. Several types of commercial traps are also available and are sometimes effective in reducing numbers of sparrows and pigeons. Poison baits may also be used if other techniques do not work.

In urban areas the problem is not so much with birds roosting in buildings as roosting on buildings. High buildings with ledges and ornate stonework are the preferred sites. These ledges, cornices, and ornate stonework can be treated with commercial, sticky substances. A good quality material properly applied may be effective for several months or more, but it is messy and may discolor the building. A permanent method of disrupting starling roosts is to eliminate ledges that encourage roosting. Construction of new buildings and modernization of old ones should be planned with this end in mind. Projecting signs or decorations and offset ledges should be eliminated. Boards, sheet metal, or mortar placed on a sharp slant will effectively keep all birds off ledges or from under eaves that can be treated. Ledges can also be protected with sharp upright spines of stainless steel wires ("porcupine wires") or with electrically charged wires. The latter methods generally require the services of a Pest Control Operator or building maintenance crew. Persistent use of distress calls in conjunction with shooting of birds with shotguns has been successful in moving starling roosts from downtown urban areas.

Birds and Feedlots

Cattle feedlots are prime locations for bird concentrations, especially from about October through mid-March. Starlings, and to a lesser extent grackles, blackbirds, cowbirds, sparrows, and pigeons, are the primary species associated with feedlot damage. Feedlots have an abundant food supply and sometimes provide warmth and shelter. One of the keys to successful bird control in feedlots is knowing the seasonal cycle of the birds and also anticipating the problem. Controls implemented as soon as the birds begin to congregate are much more effective than those applied after they have already become established. Many problem birds are migratory or at least seasonal in their activities. Most blackbirds, cowbirds, and grackles are a problem only during spring and fall when migrating in large flocks. In southern Illinois, however, they establish winter roosts. Starlings, although not totally migratory, also gather into flocks from late summer until early spring. During the nesting season in late spring and early summer they are well scattered and present little trouble to the feedlot operator. Sparrows, of course, are year-round residents and can be a nuisance during any season.

Economic losses to birds at feedlots are difficult to estimate. Best estimates indicate that about $175 per 1,000 starlings is lost for the six-month wintering period. Several techniques are available for controlling birds in feedlots. One of the most important considerations in using chemicals to control birds at feedlots is to determine where to place the bait. These methods have been discussed earlier in the section on controls. Sometimes in warm weather, large fly populations at feedlots may attract and hold large numbers of birds. Therefore, an effective fly control program may also reduce a bird problem.

In many feedlot damage situations it will probably be necessary to use an integrated approach. Most toxicants used in conjunction with scare devices are not effective unless used to concentrate birds into one area. Live traps may also supplement the other techniques. Wherever possible, roosting or nesting sites should be eliminated, and care should be taken to avoid feed spillage. Every situation is unique. It is important that you consult with people knowledgeable in bird control before designing or implementing a major bird control program. Some bird problems at feedlots are among the most difficult wildlife damage problems there are to solve. Persistence is the key to success.

Fruit Protection

Frightening devices are usually effective for protecting vine and cane fruits, especially in small to moderate-sized areas. Tree fruits can also be protected by noise devices, but more time, equipment, and persistence are required. Propane or acetylene exploders have been effective in orchards and vineyards against starlings, grackles, and blackbirds, but not as effective against robins, cedar waxwings, warblers, juncoes, orioles, and so forth. Rope firecrackers have about the same effect as exploders, but cover a smaller area. In using either device, it is important to place it well above the tops of the trees or vines if at all possible. Shellcrackers or ordinary shotgun shells are useful as a supplement to automatic noise devices because they will move large flocks of birds more effectively.

Relatively inexpensive cloth or plastic netting is often best for fruit or vegetable crops. Plastic twirlers, cloth strips, suspended pie tins, and other moving objects help to reduce damage, especially in small areas. Shredded newspapers wrapped around posts may reduce damage in small fruit patches or vineyards. Lethal measures are not very effective in reducing fruit damage. They are also hazardous and may endanger protected species. Use of decoy traps can provide relief in many situations. Traps should be kept well supplied with food and water, and protected species should be released. Methiocarb, now registered as a repellent for control of bird damage to cherries and blueberries, is being studied as a repellent on milo and sunflowers.

Agency Responsibility

The primary objectives of bird damage control in Illinois must be to prevent or minimize losses, diseases, and nuisance problems caused by birds. The Federal Migratory Bird Act places responsibility for managing migratory birds with the U.S. Department of the Interior through the Fish and Wildlife Service. Illinois law places responsibility for managing nonmigratory birds with the Illinois Department of Conservation, Fish and Wildlife Resources. All birds except starlings, house sparrows, and ferrel pigeons are protected by Illinois law, and a permit must be obtained before any lethal control can be used. Permits can be obtained through the Division of Fish and Wildlife Resources in Springfield or through the local conservation police officer. Plans for decoy traps and leaflets on other controls can be obtained from the U.S. Fish and Wildlife Service, Room 105, 600 E. Monroe, Springfield, Illinois 62701 (217-492-4308).

Control of Rats and Mice

R.D. Ogden

Rats and mice have been among the most persistent and damaging pests of man since the dawn of history. Because they are very adaptable, they live in close association with man but remain wild and undomesticated.

RATS

Biology

To control rats, it is helpful to understand certain of their behavior patterns. Because they are social animals and live in colonies, nesting close to one another and sharing a food source, they can be controlled with fewer bait replacements than are needed for mice. They will, however, travel no farther than necessary to obtain food and water. In urban areas, rats stay on their own block and are usually restricted to smaller areas within the block. By reducing, concentrating, or eliminating food sources and harborages, competition is increased, the reproductive rate decreases, and mortality and dispersal increase.

Rats have rather poor vision, but their sense of smell, taste, hearing and touch are quite highly developed. Even though they are easily frightened by sudden or unusual sounds, they are often quite active in noisy locations. They prefer to run next to walls or other surfaces that they can touch with their whiskers as they run. They constantly explore and reexplore their surroundings but are wary of new objects or changes in their environment. They approach new objects cautiously and may even avoid them for the first few days. Even a change in position of a familiar object causes suspicion. Therefore they may avoid traps and bait boxes the first night or two. Even changes of light, noise, or other factors may upset the rat and make him more wary, so, when putting out bait or traps, avoid changing anything else in the rat's environment.

Rodents' need for food is influenced by temperature, amount of available drinking water, and the amount and kinds of available food. Rats prefer good-quality food, so the bait must be as good as or preferably better than the rat's regular food.

Rats that have become conditioned to eating a particular food approach new food with much suspicion and taste it cautiously. If it tastes bad or makes them sick, they will not eat it again. This reaction is called "bait shyness." Once the rat finds a food it likes, however, it will fill itself in one feeding. Thus, when you are putting out bait for rats, you can often get effective control by using a bait that is identical to the food the rats are using.

If a different food is used as bait, prebaiting for several nights with unpoisoned bait will increase bait acceptance. Another advantage of prebaiting is that the weaker rats are usually the first to investigate a change, so you will trap or kill the weaker, nonbreeding rats first and the dominant rats may become bait or trap shy and remain to breed. Prebaiting or placing unset traps ahead of time will help overcome this reaction.

A knowledge of rat water requirements is also useful. Rats require free water to drink if they are feeding on dry foods. If water sources can be eliminated, liquid baits are very effective.

Control

Once you establish where the rats are living, feeding, and traveling, the first step in controlling them is the elimination of their shelter, food, and water. Sanitation is the backbone of a successful rat-control program whether the structure is a barnyard, feedlot, residence, office building, or food-handling business. Obscure corners and shelves and under and in such areas as cabinets, worktables, lockers, and equipment must not be overlooked or neglected.

Outside harborage areas should also be given attention. Grass, weeds, and other vegetation near buildings should be kept closely cut. Debris such as lumber, rock piles, rubbish, old equipment, and construction materials must be eliminated, and items that must be kept should be stored at least 18 inches off the ground and 12 inches away from walls or fences. Spaces such as under loading docks and outside storage buildings or sheds must be blocked off so that rats cannot gain entry. Also, old rat burrows and holes should be filled in with earth.

Ratproofing

Rat control is impossible in many buildings because their construction permits rats to get in faster than they can be killed. In such cases, it is necessary either to accept a lesser degree of control than is normally desirable or to ratproof the structure to allow adequate control. It is impossible to list every conceivable condition where ratproofing may be necessary, but every possible route or rat access to a building or to storage bins must be considered. A judicious use of sheet metal, hardware cloth, and concrete will usually give the desired result.

One of the principal places of entry for rats is through the space under exterior doors. The bottoms and edges of these doors can be built up with wood so that no opening is greater than 0.5 inch. The doors can then be covered with a metal cuff. Where wood doorjambs are susceptible to gnawing by rats, they can also be covered with sheet metal (24 gauge or heavier).

Openings such as windows, coal chutes, ventilating fans, and foundation vents can be ratproofed by tightly covering the opening with 19-gauge hardware cloth that has openings not larger than 0.5 inch. Holes through wooden walls can likewise be covered with hardware cloth or sheet metal, and holes through masonry walls should be cemented shut.

Pipes and wires running up outside walls should be protected with metal guards. Grain bins and corn cribs should be protected with sheet metal around the bottom.

Use of Poisons

After you have tried to control rats as much as possible through sanitation and ratproofing, the next step is the use of poison baits or traps.

Perimeter control is very important because it intercepts rats before they invade buildings, bins, or sheds. Burrows must be gassed and sealed. Weatherproof, permanent bait stations plus weatherproof poison baits should be strategically placed along predetermined invasion routes. Bait stations should also be placed along all potential avenues of entry, such as doorways and basement windows, and along building walls or shipping docks.

Because rats tend to feed on things familiar to them, using the proper bait will often have more bearing on results than the choice of rodenticide or bait placement. As a general rule, Norway rats (the species commonly found in the Midwest) prefer meat and fish, but even if their favorite food is used, prebaiting may be necessary to gain the rats' acceptance of the bait. The bait material, of course, must be the same during both periods. While prebaiting is useful for controlling "difficult" rats with quick-acting rodenticides, it is too costly for routine or large-scale use and is unnecessary when you use anticoagulants. Test baiting is also a useful technique to determine which baits rats prefer, the number of baits needed, and where they should be placed.

Most poisons must either be mixed in a water solution (where possible) or added as solids to bait materials that are attractive to rats. All bait materials should be fresh and must not taste or smell of chemicals. Anticoagulant poisons are commonly mixed with cereal baits such as corn meal, rolled oats, or cracked corn together with corn oil, peanut oil, sugar, molasses, or similar substances that may add to their attractiveness. Baits should be well mixed so that the toxicant is distributed evenly throughout. Meat, fish, canned cat or dog food, cereals, fruits, vegetables, nuts, and many other baits are also used. Baits may be ground, sliced, or cut into cubes although crumb-sized or sloppy-paste baits are preferable to reduce the possibility of rodents' carrying baits to other areas. All recognizable foods (such as peanut butter) should be prepared in such a way that they are made unrecognizable (e.g., by dyeing green or red).

If you mix your own baits, follow the directions on the registered label. Do not use more than the recommended amount of any poison because to do so would increase the danger of the bait to man and domestic animals and might decrease the bait's acceptability to the rats. Too low a concentration, on the other hand, will lead to incomplete control.

Bait should be placed in rat runways wherever possible. Solid bait should be placed in small cups or dishes so that it can be easily picked up when it is no longer needed. Place all bait close to walls and near doorways wherever possible. When practical, baiting should be done in the late afternoon so that the bait will be fresh at dusk when the rats become active.

Because rats often feed in one place, a small number of bait stations will be sufficient. The amount of bait needed can usually be determined after one night of baiting and depends upon the number of rats present and the toxicant being used. Use enough bait to feed all the rats present, but do not put out more bait than the rats are likely to consume because extra bait will create a hazard to pets and children.

Because bait must be placed so that it is not readily accessible to children, pets, and domestic animals, bait boxes will be needed in some areas. Basically three types of containers are used for rodent bait. (1) Bait trays are used for dry, wet, or liquid baits. They have no top, offer little or no protection to the bait, and do not prevent pets or children from reaching the poison. (2) Covered bait stations are designed to confine the bait, to protect it from the elements, and to avoid environmental contamination but not to provide safety protection to pets or children. (3) Safety bait stations are constructed of materials that will protect the bait and are designed to prevent pets and humans from having ready access to it. Such containers can be locked to discourage tampering.

Several kinds of rodenticides are available. They are commonly grouped into two categories: (1) anticoagulants and (2) single-dose or quick-acting rodenticides.

Anticoagulant Poisons. Although most anticoagulant formulations are available only for use by specialists, some of the anticoagulants are available to the general public as ready-to-use bait, concentrates to be mixed with baits or water, weatherproof pellets, paraffin blocks or cakes, and tracking powders. Whether they are to be used inside or outside, you should determine the moisture conditions and employ the appropriate formulations. For example, a loose grain bait would not be appropriate for use in a sewer nor a paraffin block in a hot boiler room.

The anticoagulant rodenticides, which include the hydroxycoumarin compounds (Warfarin and Fumarin) and the indandione compounds (Pival, diphacinone, chlorophacinone, and PMP), act by disrupting the normal blood-clotting mechanisms, causing the rats to die of internal hemorrhaging. They are mostly slow acting and take several days of continuous feeding before a rat dies, so a single dose is seldom lethal. *Baits must therefore be made available continuously for 5 to 12 days,* and reasonable control of a rat population may not occur for two weeks. (Single feeding anticoagulants are now being marketed and, if successful, will be very useful in rodent control projects.)

One advantage of anticoagulant baiting is that bait shyness does not develop, primarily because there is no violent reaction to feeding. The action of the poison is apparently painless, and rats do not suspect any danger. Unfortunately, however, anticoagulant baits do not cause rats to go outside before dying, and odor problems will develop if the rats die indoors. (For control of odors, see the last part of the section on mouse control.)

Another advantage of anticoagulant baiting is that the necessity for repeated doses is a built-in safety feature for most animals. Pigs, cats, and dogs, however, are especially susceptible and have succumbed to a single dose of anticoagulant. A useful antidote, vitamin K, is available to veterinarians for treating anticoagulant poisoning.

Thus, although anticoagulants are considered relatively safe, they must still be used in such a manner as to protect the public and domestic animals. You should closely follow the recommendations of the manufacturer and label directions for mixing and safe handling. The concentrations recommended on registered labels should be adhered to for maximum effectiveness and to prevent increasing the hazard or reducing rodent acceptance. The bait should be presented in a safe manner so as to preclude contamination of food or food stuffs. Exposure within a building should be at floor level. Open bait trays can be used indoors only if placed in areas not readily accessible to the public or domestic animals.

When baiting outdoors, place all bait in burrows, tunnels, or covered rodent bait stations or deep into holes. All dry bait should be inspected at least once a week and, if it is insect infested, moldy, or otherwise unattractive to rats, it should be replaced with fresh bait. Daily baiting is necessary when you use perishable baits such as fruits and vegetables. Bait supplies should be available to the rats at all times. Mixed-cereal or solid bait should be placed in waterproof containers in a cool, dry place if stored for a considerable length of time. Upon completion of the control program, pick up and dispose of all bait containers that are accessible to the public. It is also desirable that you pick up and destroy the dead rats.

Single-Dose Poisons. The single-dose or acute rodenticides form a second group and include the more toxic baits: zinc phosphide, strychnine, norbormide, and red squill. Each poison has special characteristics, uses, and hazards, and all should be well understood. These poisons not only kill rodents but are dangerous to man, pets, and domestic animals.

Zinc phosphide is a toxic and effective rat and mouse poison that has been used successfully for many years. It is a black powder with a distinctive odor that makes it unattractive to people and to pets. Some zinc-phosphide rat poison comes with an emetic that gives additional protection for most nontarget animals. Its safety record is very good, but it still requires special handling and mixing in a well-ventilated area. Although (contrary to long-standing belief) zinc-phosphide baits remain toxic for long periods of time, its quick action, effectiveness, and low hazard make it one of the most useful rodenticides.

Strychnine sulfate and strychnine alkaloid are sometimes used as rodenticides, particularly on poisoned seeds for mouse control. The sulfate is preferred for treating grains because it will soak into the kernels, whereas the alkaloid must be coated on the outside with starch and other adhesives. These poisons do not normally give good results in rat control, however, because of their extremely bitter taste and fast action. Because strychnine is so fast acting (death can occur as soon as 12 minutes after eating) and is toxic to all forms of life, it is a very hazardous material and must be used in only special situations and with great care. Because use of strychnine creates secondary hazards, pick up all dead animals and dispose of them either by burning or deep burial.

Norbormide, better known by the finished-bait trademark Raticate or the chemical trademark Showoin, is a quick-acting poison for Norway rats. Although it has shown great promise because of its quick action and safety, norbormide is not widely used because bait acceptance is poor and tolerance develops following sublethal doses. It is useful, however, for quick reduction of a Norway rat population where safety is of utmost importance.

Red squill is a quick-acting rodenticide with a natural emetic action that causes prompt vomiting except in rats, which cannot vomit. It also has a bitter taste that is objectionable to man and many domestic animals. Because of its strong taste, red squill is effective against the Norway rat only, and even with this pest a sublethal dose will cause severe bait shyness. As a result, its most effective use is for a quick reduction of a rat population over a short period of time. Red squill absorbs water from the air and becomes caked and hard, so it should be stored in tightly sealed containers. Care should be taken not to get it on the skin because it is extremely irritating.

Tracking powders (anticoagulant and single-dose poisons) can be used in enclosed areas where food materials will not be contaminated.

Poison Gases. Certain gases can be used to supplement the anticoagulant and single-dose poisons. Calcium cyanide (Cyanogas or "A" Dust), chloropicrin, and methyl bromide are used for quick kill of rodents and their ectoparasites in burrows outdoors. These gases can be quite dangerous and should be used very carefully.

Calcium cyanide is available as a dust that can easily and safely be put into burrows with foot pumps made available specifically for this purpose. The dust reacts with water vapor in the air and gives off hydrogen cyanide gas (HCN), an extremely toxic fumigant. HCN can be absorbed through the skin, especially if the skin is damp with perspiration. Calcium cyanide is used primarily in control of rats, but also for control of chipmunks, ground squirrels, and other burrowing rodents. The dust is most effective when forced into rat burrows by inserting the pump hose into the burrow and then closing the burrow to retain the gas within it. This process also aids in telling whether a burrow has been reopened and rat activity still persists. You can usually close burrows by simply stomping dirt into the hole with the heel of your shoe. Dusting should be done on a still day so that air currents will not carry the gas away or to the operator. Burrows that lead under occupied buildings should not be treated.

Chloropicrin and methyl bromide are used in much the same manner to control rodents in burrows. It is very important that label directions be closely adhered to in all control operations.

Use of Traps

In certain situations, particularly where there is danger of contaminating food products or of harming pets or children, it may be necessary to trap for rats. Many types are used: common wood-base snap traps, steel traps, live traps, and multiple-catch box traps such as the Ketch-All. The trap most commonly employed in rat control, however, is the wood-base snap trap. It may be baited, or the trigger device may be expanded and the trap used without bait. Steel traps, like those used to catch small fur-bearing animals, are less suitable for trapping rats because they usually catch the rat by snapping shut on one leg and the rat will often chew the leg off and escape.

To bait snap traps, use suitable food baits not larger than the end of the index finger. Tie the bait to the trigger of the trap, and set it in a runway. To expand the trigger device, securely attach a piece of screen wire or light cardboard (the same width as the trap) to the trigger, and set the trap in a runway so that a rat crossing the trap will step on the enlarged trigger and be captured.

In every case, the traps must be set in the rat runways. Where necessary, boxes or other obstructions (new materials or objects may be avoided for a day or so) may be placed along a wall to create a runway so that the rats will have to cross your traps. It is necessary to move the traps (about every week) and change baits frequently because rats easily become trap shy and will avoid traps baited with the same food or left in one location too long.

Although the traps with enlarged trigger devices do not need bait, it is certainly an additional drawing card. Many baits are effective, from peanut butter and cake crumbs to bacon and gumdrops. Because they tend to spoil easily, however, fresh baits should be used only where the extra attraction is needed.

A number of traps should be used, and they should be spaced within 20 feet of each other. Traps should be checked frequently and trapped rodents removed.

Other Control Methods

Ultrasonic devices are another method of control, but limitations at this time make them impractical. Most units are quite expensive and use a great amount of energy. Only under unusual conditions would it be possible to set up sound barriers that rats and mice will not pass, and they would remain effective only as long as the equipment was in proper operating condition.

Chemosterilants have been tested in attempts to develop materials to sterilize female, young, or male rats, but most of them are effective only if fed to rats repetitively. Bait shyness has been a major problem with compounds developed to date, and a permanent, effective sterility compound has yet to be developed.

MICE

Biology

House mice are very similar to young black rats. Their ears are large, their tails are as long as their heads and bodies together, and their feet are short and broad. They can be easily distinguished from small rats, however, by their small eyes and feet.

Mice cause a great deal of damage. They are gnawers or nibblers and thus tend to make small holes or other slight damage in many places rather than a lot of damage at one place. Because of their nibbling habit, moreover, they contaminate much of the material that they do not destroy.

Mice have keen senses of touch, smell, and hearing. They can run, climb, jump, and swim very well although they cannot climb as well as most rats. They prefer to feed at night and are most active at dusk. Although under continuous light mice will be active during the quietest periods, mouse activity during the day usually indicates a very heavy infestation.

House mice eat about the same foods as humans, including cereals, seeds, fruits, and vegetables, and are especially fond of sweet liquids. They can survive on extremely small amounts of water, and this trait has led to the incorrect belief that they can live without water. Although mice are unable to survive under carefully controlled conditions in which no water is accessible, their entire water requirements can be provided by moist food, and free water is not necessary. Nevertheless, water baits are readily accepted and may be more useful than dry baits in some situations.

Unlike rats, mice are not suspicious of new foods and will eagerly sample them, which makes it easier to bait for mice. They will, however, feed on other foods if for some reason the bait is not attractive. Also, because mice nibble, feeding as often as 15 to 20 times each day on many different foods and consuming only a small amount of food each time, it is difficult to get them to take a lethal dose of a poisoned bait. Thus, as with rats, there is no perfect bait for all situations.

Control

The first step in mouse control is to look for signs of mouse infestation so that you will know the extent of the problem before you begin control measures. Fresh droppings are a sure sign of mice. Care must be taken, however, to distinguish their droppings from those of the larger roaches that are frequently found in the same areas. The droppings of both are 0.25 inch long, but the mouse's are pointed on the ends whereas the cockroach's are blunt ended and ridged down the sides. Mouse nests are frequently found in and near their food supply. The nest is made from almost any soft material chewed into small bits to make a soft bed. Another sign of infestation is holes. Holes gnawed by mice are usually small and clean cut rather than large and torn like rat holes.

Mouseproofing

Buildings can be mouseproofed by closing openings around pipes, doors, windows, holes in walls, and other places similar to those closed for ratproofing. Because mice can often enter any opening larger than 0.25 inch, it is frequently difficult to find all openings.

Use of Poisons

The same poisons used for rat control (with the exception of red squill) will give effective mouse control. To bait for mice, place many smaller baits rather than a few large baits because mice do not usually travel very far in search of food. Make it easy for a mouse to find your bait. Place cups of bait actually touching the walls along walls and other runways because bait placed several inches from a wall may be bypassed consistently. Be very careful to bait near all openings to the outside of the building where mice may enter and also next to all inside doorways that remain open. Be very careful to replace baits frequently because mice are not attracted to old, dirty bait. Tracking powders can be used in confined spaces where food material will not be contaminated.

Use of Traps

Trapping of all kinds, particularly with the automatic trap, is very desirable in such places where baiting with poisons is hazardous. Traps should be placed within 10 feet of each other.

Bait for mouse traps must be carefully selected. Cheese, although frequently the choice of the housewife, has no place in large mouse-control projects. Bacon, nuts, hard sugar candy, gumdrops, peanut butter, and small sardines are usually the best baits. Solid baits should be tied firmly on the trigger. If mice are removed from traps as they are caught, it is quite possible to catch a dozen or more with the same trap without changing the bait.

Odor Control

Following poisoning, it is desirable to remove dead mice for the same reasons given in the rat-control section. Frequently, however, carcasses are located in wall voids or other inaccessible places in buildings. If the dead rodents cannot be retrieved, the area should be ventilated as well as possible, and a masking agent should be applied. If a carcass is located in a wall void, a pint of water mixed with a masking agent can be poured or forced into the area, and the odor usually will be eliminated immediately. If the rodent cannot be precisely located, a masking-agent solution can be applied more generally to the affected area. In severe cases, it may be necessary to use a mist or ULV machine in the area. Repeated applications may be necessary until the carcasses dry up. Several masking agents are available, including Neutroleum Alpha, isobornyl acetate, and Styamine 1622. Label directions should be closely followed.

Control of Vertebrates Other Than Rats and Mice

R.D. Ogden

Bats

Being nocturnal animals, bats roost by day and fly by night in search of night-flying insects, which are their principal source of food. In nature, they roost in dark places such as in caves, in tree cavities, and under overhanging rocks. They have, however, easily adapted themselves to living in buildings, where they roost under hollow floors and in attics, hollow walls, chimneys, and similar places and thus are of concern to farmers and homeowners. A few species live individually, but most congregate in large colonies, so infestations are frequently severe. Droppings and urine deposits under roosting areas have a strong, disagreeable, and persistent odor that is quite characteristic and will usually serve to attract new bats to a roosting place even if the original inhabitants have been removed.

Because bats are easily attracted to areas where other bats have been roosting, close all openings through which they may enter. Smaller bats can crawl through openings as small as 3/8 inch, so no opening larger than 1/4 inch should be left. Larger openings should be closed entirely with wood, oakum, metal, or concrete, except where ventilation is required, in which case 1/4-inch mesh hardware cloth can be used. One way to be sure all bats are out of the building before closing openings is to close all but a few openings, wait several days until the bats become accustomed to using those that are left, then, when the bats are all out at night, close the remaining openings.

In addition to the general nuisance and odors associated with bat infestations, the animals also harbor ectoparasites such as mites and bat bugs that may leave the nesting area to attack humans in the building, especially when the bat population is removed. Therefore, a part of all bat-control jobs should be to kill any ectoparasites that may remain and try to migrate.

Dead bats and droppings should be removed from the premises whenever possible because the odor from the decaying bodies can be quite offensive. That odor and the odor remaining from the roost can be covered up by paradichlorobenzene (PDB) or any deodorant used to mask the odor of dead rats.

Anyone engaged in any sort of vertebrate pest control has an increased likelihood of contacting rabid animals. Bats should therefore never be handled, dead or alive. They have needlelike teeth and can bite severely. When working with bat infestations, you should use a beekeeper's helmet, gloves, and coveralls. Any bat that acts in an abnormal manner, such as fluttering around on the ground, may be rabid and should be avoided or handled with tongs. Because rabies in man almost always results in death, any bat causing a bite should be captured with its brain intact for examination by health authorities.

Tree Squirrels, Ground Squirrels, and Chipmunks

Tree Squirrels

While they generally build their nests in trees, some species of tree squirrels will settle in an unused attic if conditions are favorable. They can do considerable damage to buildings with their gnawing and will chew on cables and electrical wiring. They may also be very noisy, will bite if cornered, can cause ectoparasite problems in nesting areas, and can damage garden and ornamental plants. They are most active in the early morning and late afternoon. They feed on nuts, seeds, buds, leaves, bulbs, bark, insects, and fruit and like to store some of these foods in outdoor caches.

To control tree squirrels, first determine how they are entering a building and make every effort to seal existing openings with sheet metal or 1/4-inch hardware cloth. They can be kept from climbing trees by placing a two-foot-wide metal band around the tree trunk, three to four feet above the ground. Squirrels can also be repelled from buildings by the liberal use of naphthalene in enclosed spaces that they might enter. Frequently, squirrels will get into a building from a single overhanging tree limb. In this situation, simply prune the limb back 10 feet or more so that they cannot reach the building from it.

If the squirrels cannot be controlled by screening, repelling, or removing tree limbs, it may be necessary to kill or trap them. In cases in which the squirrel population is small, they can be controlled by shotgun. Because most squirrels are protected animals, however, you must make certain that you are not violating any laws in your trapping or killing procedures. To obtain clearance, consult your local conservation police officer. In many areas it is possible to obtain a special permit or other permission to eliminate squirrels if they can be shown to be a nuisance.

Where squirrels cannot be killed, trapping with live traps is usually the best method of control. Traps should be placed, unset, in areas where they are to be used until the squirrels become accustomed to them. Bait (peanut butter) placed by the traps will attract the squirrels to them. Once they have become accustomed to the traps, a few settings will usually capture enough squirrels to eliminate the problem.

Ground Squirrels

Ground squirrels (sometimes called "gophers") often cause damage to lawns, golf courses, and gardens by burrowing and by digging up newly planted seeds. These animals are active from late March until October, at which time they enter their underground burrows to hibernate. They eat roots, fruits, seeds, insects, and green vegetation. They are nervous, excitable animals seldom found far from their burrows. Their preferred habitat is open fields or brushy areas, so they are not usually found in forests or in damp areas. They can be distinguished from tree squirrels by their shorter and less bushy tails and by the fact that they live underground and are excellent burrowers but poor climbers.

Ground squirrels can be controlled with poisons or repellents labeled for these burrowing rodents or with traps. PDB can be used as a liquid fumigant or repellent. The liquid is poured into the burrow and then sealed with dirt. Trapping is effective for removing small infestations of ground squirrels. Rat snap traps, small live traps, or special box traps should be placed in shallow depressions near the burrow entrance. The animals can be lured into the traps by sprinkling small amounts of grain on the earth covering them or around them.

Chipmunks

Although they generally add to the enjoyment of the outdoors, chipmunks may occasionally become pests by burrowing under buildings and into flower beds, lawns, and golf courses. These small rodents are often confused with the 13-lined ground squirrel, which is a larger animal with 13 alternating light (with spots) and dark stripes. Chipmunks have solid light and dark stripes that also appear on the head and nose. Another characteristic of chipmunks is that they run with their tails up over their backs. They are active from March to October, spending most of the winter in their burrows, which are usually lengthy, covering 30 feet or more. They remove the dirt from the burrow and scatter it away from the burrow entrance. In addition to underground burrows, they are also found in walls and wood piles. They feed on seeds, nuts, grains, fruits, and insects.

Chipmunks can be controlled by trapping, shooting, or using poisons labeled for these burrowing rodents. Rat snap traps or small live traps baited with nutmeats, sunflower seeds, peanut butter, corn, or rolled oats and placed around rock piles or logs or near burrow entrances are usually effective. Where firearms may be used, a small-gauge shotgun is usually preferable and is most effectively used in early morning or late afternoon.

If the chipmunks are alive, they can cause serious bites. In fact, gloves or tongs should be used to handle all vertebrate pests, dead or alive, since they or their ectoparasites may carry disease.

Skunks

The striped skunk is the most common species in Illinois. Skunk damage can be costly because: their odor is nauseous, they are a reservoir in the transmission of rabies, they destroy turf in golf courses and lawns while digging for grubs, they kill poultry and birds, and they harbor ectoparasites.

Skunks are most active after dusk. They emerge from their burrows to feed on grubs and other insects, small rodents, garbage, birds and their eggs, fruits, and berries. If approached, the skunk may eject its musk. Its aim is very good, and the material can be squirted more than 10 feet. If a skunk is aggressive, it should be avoided because it may be rabid.

Skunks are usually a problem if they have gained access to the space under a building. To exclude them from such places, close all but one opening and then sprinkle a little flour in front of it. Examine the flour after dark and, if the tracks show that the animals have departed, close the opening and seal it securely with cement, sheet metal, or wire netting. Another way to get rid of skunks is to throw a light on the area they frequent. To prevent skunks from digging in a lawn, grubproof the turf with an insecticide.

If a skunk must be trapped, use a box trap baited with fish, bacon, chicken parts, or fresh eggs and covered with old burlap sacks or tarps. The trap should be located so that it and the animal can then be removed easily to a release site.

If skunk odor gets on clothing or under buildings, it can be neutralized by liberal use of a deodorant such as neutroleum alpha. Vinegar or chlorine bleach in a weak solution is also suggested for removing the odor from clothing or pets.

Moles

While searching for the earthworms and insect larvae that are their principal food, moles damage ornamental plants by destroying their roots. In addition, their burrows deface lawns and the gardens adjoining them.

Moles are subterranean and rarely come above ground. Their nests are usually deep beneath the protective cover of a large stone, tree, sidewalk, or roadway. Although moles are almost blind, they have keen senses of smell, touch, and hearing. They are most active on damp, cloudy days in spring and fall and have been reported to burrow 100 yards in a single 24-hour period.

Moles can be indirectly controlled by grubproofing lawns and gardens. Although this method does not kill the moles, it forces them to go elsewhere to find food. They may still damage lawns, however, while searching for food or just wandering.

You can buy traps designed for mole control, such as the choker trap and harpoon trap. They should be used according to the manufacturer's directions.

Liquid PDB and calcium cyanide (Cyanogas) are approved for use in fumigating burrows. Follow the label directions closely in applying these gases. Do not put out poisoned peanuts. Their use is ineffective and dangerous.

Snakes

In their natural surroundings, snakes should be left alone both because the poisonous species are dangerous and because they are generally beneficial animals, eating many rodents and insects. Snakes of many kinds, however, find their way into and around buildings. They become a problem for the homeowner in crawl areas, yards, gardens, poultry houses, and outbuildings because they frighten or bite humans, kill birds, and cause odors in warm weather.

Although few native animals are more disliked or more misunderstood, most snakes are not poisonous. Of the 116 species of snakes in the United States, only 19 are dangerous. Fifteen of the dangerous species are rattlesnakes, two are moccasins, and two are coral snakes. None of the rest need be feared. All of the poisonous species except coral snakes have vertical pupils (cat's eyes) and/or a deep pit on each side of the head between the eye and nostril.

Most snakes hibernate over the winter in burrows or dens and become active when the weather is warm, some in the daytime and some at night. When snakes are present in large numbers, an abundance of food must be attracting them. By removing their food source (such as rodents) and cleaning up debris, trash piles, compost heaps, wood piles, thick vegetation, and tall grass, you will drive snakes out of the area. If a snake gets into a building and hides before it can be found, put wet cloths near where it is thought to be and cover them with dry cloths or burlap bags. Snakes like moisture and shelter and will be attracted to this pile of materials. They can then be removed or killed by clubbing or shooting.

To keep snakes from getting in, all points where they might enter should be blocked. Snakes usually enter near or below ground level and can get through extremely small openings, so a number of modifications may need to be made to a structure to snake-proof it.

Miscellaneous Vertebrate Pests

Many other vertebrates may become pests on occasion, including coyotes, feral cats and dogs, raccoons, opossums, rabbits, pocket gophers, woodchucks, and field mice. Measures to prevent damage by these animals can be either protective (removal of food and shelter and repair of buildings to exclude the animals) or reductional (poisons or traps).

Coyotes

Sheepmen, hog raisers, and cattlemen are suffering losses because of coyotes, which are becoming increasingly abundant in Illinois. Coyotes also help themselves to poultry and waterfowl. They can be controlled by shooting or chasing with hounds throughout the year or by trapping during certain months. They are protected from trapping most of the year; however, a permit can be obtained for their control if damage can be proved. They can be excluded from pasture areas by electric fences.

Feral Cats and Dogs

Originally pets, feral cats and dogs are those animals that have been driven away or allowed to stray from home and have acquired wild habits. They may invade areas such as around homes, feedlots, markets, food plants, warehouses, garbage containers, and dumps and may contaminate food, spread ectoparasites, bite and scratch, kill birds and other animal life, and carry diseases of man and other animals such as rabies.

Most of these cats and dogs are active at night and are very cautious, secretive, and solitary except during breeding time. If they must be handled, all precautions should be taken to avoid scratches and bites. Trapping with baited (fish or meat) box traps is the only approved method of control in heavily populated areas. Traps should be set at or near places where strays can be expected to visit, such as around garbage cans or other sources of food. PDB and naphthalene aerosols are available for use as repellents both indoors and outdoors, but they are effective only in small areas or where the animal can be confined. In rural areas, shooting individually recognizable animals is effective.

Raccoons

Common throughout most of the United States, raccoons are a protected furbearing animal in Illinois. They become problems in outbuildings, attics, garbage containers, poultry houses, and cornfields, where they are noisy, overturn garbage containers, kill poultry, and damage corn plants, especially when the ears are in the milk stage. These animals are intelligent, strong, good climbers, and persistent. They are usually active at night and remain in their dens in haylofts, attics, trees, hollow logs, or burrows during the day. In addition to feeding on insects, frogs, and fish, they will eat just about anything man will eat. The most satisfactory method of control is trapping with wire or box-type traps baited with fish, chicken parts, or corn on the cob.

Opossums

These sluggish animals nest in hollow logs and trees and in rock dens, but they often invade crawl areas, attics, lawns, and yards, where they create a nuisance, kill poultry, cause odors, bite, and spread their ectoparasites. Opossums will eat practically anything available, animal or vegetable, often feeding on the carcasses of animals killed on highways. They can be readily taken with box traps baited with fish, putrid meat, or chicken parts.

Rabbits

The value of rabbits as game animals (protected in Illinois) is often outweighed around the home and farm by the damage they do to ornamental plants, fruit trees, and vegetable gardens by consuming plants and gnawing the bark of shrubs and trees. They also spread ectoparasites. Rabbits are active throughout the year, feeding mostly in early morning and late afternoon on leaves, stems, buds, and bark. They prefer areas of heavy vegetation, brush, and piles of debris. By eliminating those harborages, you can often remove rabbits from the area of concern. Other control or protective measures include wire guards and fencing for yards, gardens, and individual plants; the use of repellents such as naphthalene dust, Arasan, and other commercial preparations labeled for rabbit control; trapping with box traps baited with apples, lettuce, or carrots; and shooting (where permitted).

Pocket Gophers

These rodents get their name from their fur-lined, pocketlike cheek pouches in which they carry food. They live in underground burrows that may be several hundred feet in length, ranging in depth from a few inches to several feet, with sometimes several gophers inhabiting a single burrow system. Unfortunately, they dig these burrows in lawns and gardens, pushing the soil from the burrows into mounds that are built in the shape of a horsehoe around the burrow opening, making sometimes 100 or more mounds in a season.

Gophers are active all year but are most active in late summer and fall, when they dig shallow burrows to get roots for winter, usually storing the roots in small chambers within the burrow. In late summer and early fall, many young gophers are forced to the surface and wander about searching for a home. They will inhabit any unused burrow. Control is best accomplished by trapping or using poisoned baits that are labeled for gopher control. Small spring traps are made especially for trapping pocket gophers. Liquid PDB can also be used as a repellent and fumigant in burrows.

Woodchucks

Woodchucks often burrow under foundations or rock walls, causing them to crumble. They also cause considerable damage to crops like soybeans. They hibernate during the winter. They can be controlled by shooting or trapping or by poisoning or gasing the burrows. Woodchuck or "gas" cartridges can be placed in the burrow and the entrances sealed, but these cartridges should not be used under wooden floors, walls, or any other combustible material. February and March are the best months for control because active woodchuck dens are easiest to identify at this time. Woodchucks are completely protected in Illinois during April and May, and throughout the year you must have a permit from the Department of Conservation before you use the woodchuck cartridges.

Field Mice

To find food and shelter, field mice often invade homes, yards, and gardens in the winter. They can create a nuisance and damage ornamental trees and shrubs by root pruning and trunk or root girdling. Extensive damage may occur to orchards during periods of heavy snow cover. Because they move in from adjacent fields and bushy areas, they can usually be eliminated by mowing those areas closely. Mowing of orchards or maintaing bare areas near the base of the trees helps keep populations down. They can also be controlled by wrapping tree trunks, by the proper use of wood-base snap traps and toxic baits labeled for such use, and by making structural modifications to exclude mice from buildings.

Suggestions for Minimizing Bee, Fish, and Wildlife Losses from Pesticides

G.C. Sanderson, R.C. Hiltibran, and E.E. Killion

It may be almost impossible to use pesticides without the possibility of endangering some nontarget species, such as fish and wildlife. However, through prudent use, the hazards to fish and wildlife from the use of pesticides can be substantially reduced. Here are some precautions to follow:

1. Apply pesticides according to the instructions given by the manufacturer and the Cooperative Extension Service.

2. If more than one pesticide is available to control a specific pest, use the pesticide least toxic to nontarget organisms. (Usually this information is not readily available to the applicator in the field. Also, frequently there is not much difference between pesticides in toxicity to nontarget organisms.)

3. Avoid drift. (Most applicators are aware of drift problems. However, problems are caused by the fact that climatic conditions often change after the application of a pesticide, and these changes cannot always be predicted.)

4. Follow instructions in disposing of pesticide containers.

5. In wildlife and aquatic areas use ground equipment so that pesticides can be confined to specific target areas.

6. Make sure that pesticide-treated seed is not readily available to birds or mammals.

7. Do not apply to water pesticides that are not registered for aquatic use. For application to water, use only those pesticides registered by the federal EPA for aquatic use (Rule 203h, Water Pollution Regulations, as amended).

8. If a pesticide is extremely toxic to fishes, avoid applying it in the immediate watershed, including ditches and channels that drain into bodies of water.

9. Wash application equipment properly, and do not permit wash water to enter any water area.

Some Characteristics of Animal Populations in Illinois That Are Helpful in Understanding the Wildlife-Pesticide Problem

First of all, it should be emphasized that we know little about the overall effects of any pesticide on any population of wild vertebrate animals. Certain general facts have been established, however. A considerable amount of data is available on the acute toxicity of various compounds to a variety of species in captivity. Also, a limited number of studies have been made on the rate of recovery of a population following one or more applications of a pesticide to an area. In populations of wild vertebrates some pesticides may produce great mortality both directly and indirectly through the food chain. It has been shown that persistent chemicals such as the chlorinated hydrocarbons are concentrated from the bottom of the food chain to the top of the food chain so that animals at the top of the food chain often accumulate heavy dosages of the toxin. As a result, whole populations may lose their reproductive capacity. Accumulations of organo-chloro insecticides through the food chain may have reduced the reproductive capacity of the bald eagle, duck hawk, and other raptor populations both in Europe and North America, as well as certain species of fishes and fish-eating birds such as loons, cormorants, and pelicans.

While these discussions refer to all wild vertebrates in general, most of the remarks and examples will refer to birds. Because of their migratory and highly mobile nature, a greater number of birds are susceptible to poisoning from a single application of pesticide than are mammals.

Certain ecological principles should be obvious to everyone. The simpler the habitat, the fewer organisms it supports, both in terms of the number of organisms and the variety of organisms. Conversely, the more complex the habitat, the greater the number and variety of organisms. For example, in summer, bare plowed ground usually supports only about 3 to 5 native species of birds with only about 1 bird for every 2 acres. At the other extreme is forest, which supports about 80 to 85 nesting species of birds with about 5 to 8 birds per acre. Of the agricultural habitats in Illinois, corn and soybean fields have the poorest bird populations, essentially the same as plowed bare ground; wheat fields are only slightly better, but oat fields have conspicuously higher bird populations. Grasslands and hayfields are very rich bird habitats with 40 to 70 native species in summer and 3 to 5 birds per acre. The shrub borders and hedges at the edges of cultivated fields have some of the densest populations of birds of any Illinois habitat. Marshlands also have high populations and many species. In Illinois, the prairie-grassland and marsh-dwelling species are the ones in greatest danger of extermination.

Regrettably, the effects of pesticides applied to a wheat field do not stop at the borders of the wheat field because animals, especially birds, from adjacent fields may pass through the poisoned wheat field or even forage at its boundaries. A study made in Illinois in 1964 indicated that in a single breeding season two successive populations of birds were killed in a hayfield from the effects of one application of 1/4 pound of dieldrin on a nearby wheatfield. The hayfield was not sprayed, but the birds there died. A third population of birds that moved into the hayfield within a month of the spray date was unable to produce fertile eggs.

Populations of birds shift greatly from season to season. Between April 15 and June 10, and again between September 1 and November 15, the bird populations in all parts of Illinois reach their greatest heights. Over 200 species are present in the state, and the numbers are many times the normal breeding population. Many of these species are highly insectivorous. After October 1, more and more waterfowl appear in the wetlands of the state. The songbird populations penetrate every habitat, but are most abundant where there is some woody vegetation. Populations of songbird migrants in open field habitats probably reach their peak in late March to mid-May and in October and early November. Fortunately most of the migrants do not spend time in plowed fields, or corn or bean fields, i.e., bare fields. An exception is the golden plover, which passes through the state by the thousands in April and May; these birds regularly feed on bare fields and grasslands and concentrate particularly around rain pools.

In Illinois, bird populations reach their lowest levels in the northern third of the state in the winter (Jan. 1 - March 1), but in the southern third of the state winter populations are even higher than the summer populations in practically all habitats.

Some Useful Facts about Pesticides and Fish Mortality

Fish kills in ponds and streams are caused by insecticides, herbicides, liquid fertilizers, barnyard wash, and numerous other factors that affect the supply of oxygen. Specifically, some insecticides are much less toxic to fish than others, so proper selection and use of insecticides will reduce potential danger. Extreme care and caution are urged in applying any pesticide near streams and ponds. If toxic agents are applied in a short section of a stream or drainage channel, fish and other animals may be killed as the toxic agent flows downstream. When a fish kill occurs, examine all possible causes, including pesticides.

The accompanying table may be of some help to you in answering questions about insecticides and fish kills. We compiled this information from several sources. In using the data, consider the stability of the compound, its tendency to store in fat, method and rate of use, affinity for soil particles, and solubility, as well as exact toxicity.

LD_{50} is the number of milligrams (0.001 gram) needed per kilogram (1,000 grams) or 2.2 pounds of body weight to kill 50 percent of selected healthy laboratory test animals, usually white rats. Both oral and dermal toxicities are included in the table.

Also in the table, LC_{50} means the amount of pesticide in parts per billion needed to kill 50 percent of the test fish in a 24-hour period in an aquarium. Note that this information indicates those killed immediately after exposure. Low levels of some pesticides may be stored in fat tissues over a period of weeks. Theoretically, this stored material could cause fish mortality if the fat were suddenly used under stress and the pesticides were redistributed throughout the fish's system.

The LC_{50} and the rate per acre-foot of water are based on laboratory tests on 2-inch bluegills exposed to that concentration for 24 hours at a water temperature of 75° F. When they were exposed for 96 hours, the concentration required to reach the LC_{50} was much lower. Toxicity varies greatly with fish species, chemical, and formulation of the chemical. The LC_{50} for naled (Dibrom) to rainbow trout was 70 ppb and for bluegill, 200 ppb; for trichlorfon (Dylox) it was 28 ppm for trout and 5.6 ppm for bluegill. Thus this table serves only as a guide. Bluegills were used rather than trout because they are a popular Illinois fish species.

Some Facts about Pesticides and Bees

Bees are highly important as pollinators of apples, pumpkins, clovers, cantaloupes, watermelons, blueberries, cucumbers, squash, and other crops in Illinois. Honey bees visit blooming soybeans in all areas of the state and improve yields of some varieties. The bees also visit sweet corn and field corn tassels when they are shedding pollen. Growers should consider the bees' presence before applying insecticides during soybean bloom and when corn is pollinating. Highly poisonous to bees of all kinds, some common insecticides may cause serious losses to social bees, such as honey bees and bumble bees, as well as to the less-known solitary bees, such as alkali bees and leaf cutter bees. Efficient management of control

Insecticides, Their Common Agricultural Rates, Extent of Use, LD50 to White Rats and Other Animals, 24-Hour LC50 to Bluegills, and the Calculated 24-Hour LC50 in Pounds of Toxicant per Water Acre 3 Feet Deep

Insecticide	White rats Approximate LD50, mg./kg. Oral	Dermal	Common agr. rate, (lb./A.)	Use in Illinois	Birds[a] LD50 mg/kg	Fish LC50, ppb	Lb. toxicant per ft.-acre for blue-gill LC50	Comments apply only to fish kill
toxaphene[b]	85	925	1.5	Moderate	31	7	.02	Extremely toxic to fish. Do not use in the vicinity of streams or ponds.
DDT[b]	115	2,510	...	None	595	7[c]	.02	
azinphosmethyl (Guithion)[d]	12	220	.5	Moderate	75	8?	.02+	
aldrin[b]	49	98	1.0 to 1.5	Heavy[e]	6	10	.03	
phorate (Thimet)[d]	1	3	1.0	Heavy	<1	10	.03	
rotenone	75	940+	...	None	>1,414	24	.06	
methoxychlor[b]	5,000	6,000+	1.5	Light	>2,000	31	.08	
heptachlor[b]	131	230	1.0 to 1.5	Moderate[e]	>2,000	35	.09	
diazinon[d]	92	680	1.0	Moderate	4	54	.15	Highly toxic to fish. Use great caution if applied in the immediate vicinity of streams and ponds.
parathion	12	14	.25 to .5	Light	2	56	.15	
lindane[b]	89	950	...	None	900	61	.16	
malathion[d]	1,200	4,000+	1.0	Moderate	167	120	.32	Moderately toxic to fish. Use cautiously around streams and ponds. Avoid direct application of agricultural sprays to water insofar as fish are concerned.
demeton (Systox)[d]	5	11	...	None	7	195	.53	
naled (Dibrom)[d]	250	800	.75	Light	52	220	.59	
carbofuran (Furadan)	5	885	.75-1.0	Heavy	<1	240[f]	.60	
carbaryl (Sevin)[g]	675	4,000+	1.0 to 2.0	Heavy	265	3,400	9.2	Least toxic to fish. Reasonably safe to use around ponds or streams insofar as fish are concerned.
trichlorfon (Dylox)	595	2,000+	1.0	Light	37	5,600	15.1	
methyl parathion[d]	19	67	.25-.5	Light	8	8,500	23.0	
dimethoate (Cygon)[d]	215	505	.5	Light	9	28,000	75.6	

[a]Test bird: Mallard duck, ring-necked pheasant, bobwhite, or California quail. Toxicant administered as a single oral dose. Data from Denver Wildlife Research Center, Bureau of Sport Fisheries and Wildlife.

[b]Chlorinated hydrocarbons, aldrin (as dieldrin), DDT, dieldrin, and heptachlor (heptachlor epoxide) are stored in fat and persist as residues. Methoxychlor is less readily stored, and its toxicity is lower than many others. Toxaphene does not tend to store and is rapidly excreted.

[c]Lower than some studies show.

[d]Organic phosphates are usually not readily stored and break down in water. Some are highly toxic to warm-blooded animals.

[e]Used as soil treatments; adheres readily to soil particles.

[f]Four-day exposure for LC50.

[g]This carbamate is more residual than many phosphates but is relatively nontoxic to fish and wildlife.

programs and of bees can do much to reduce loss of bees through necessary agricultural pest-control operations. Relating spraying operations to knowledge of daily bee activity, insecticide toxicity, plant maturity, and spray drift will reduce bee losses and may mean the difference between a satisfied producer and one faced with a lawsuit.

If informed of intended pesticide applications that could damage bees, a beekeeper may be able to protect his colonies to some extent. Beekeepers are required to register with the Illinois Department of Agriculture, Bureau of Plant and Apiary Protection, 522 South Jefferson, Paris, Illinois 61944. Local county Extension advisers have a current listing of beekeepers and hive locations that are available to spray operators. Additional assistance can be obtained from the chief apiary inspector.

Relative Toxicity of Pesticides to Honey Bees

Pesticides differ greatly in their effect on honey bees. The formulation of the material plays an important role in its toxicity to bees. In general, sprays are safer than dusts, and emulsifiable concentrates are less toxic than wettable powders. Granular materials usually are not hazardous to bees. Microencapsulated formulations of highly toxic materials are extremely hazardous to bees. Penncap-M should not be used on crops visited by bees or in locations where it may contaminate other blooming crops or weeds.

Fungicides, acaricides (miticides), herbicides, and blossom thinners are relatively nontoxic. These materials and the insecticides can be placed in three groups in relation to their effects on bees--those highly toxic, those moderately toxic, and those relatively nontoxic.

Insecticides Highly Toxic to Bees

This group includes materials that kill bees on contact during application and for one or more days after treatment. Bees should be moved from the area if highly toxic materials are used on plants the bees are visiting. This group includes:

aldrin
aldicarb (Temik)
arsenicals
azinphosethyl (Ethyl Guthion)
azinphosmethyl (Guthion)
Azodrin
Banol
BHC
Bidrin
Bomyl
carbaryl (Sevin)
carbofuran (Furadan)
chlordane
chlorpyrifos (Dursban)
crotoxyphos (Ciodrin)
diazinon (Spectracide)
dicapthon
dichlorvos (Vapona) (DDVP)*
dieldrin
dimethoate (Cygon)
dinitrobutylphenol (DNOSBP)
EPN
fensulfothion (Dasanit)
fenthion (Baytex)
Gardona
heptachlor
lindane
malathion
malathion ULV
Matacil
Metacide
methomyl (Lannate)
methyl parathion
mevinphos (Phosdrin)*
microencapsulated methyl parathion
Mobam
naled (Dibrom)*
parathion
permethrin (Ambush)
phosmet (Imidan)
phosphamidon (Dimecron)
propoxur (Baygon)
Pyramat
Telodrin
Zectran
Zinophos

*Short residual activity. Can usually be applied safely when bees are not in flight. Do not apply over hives.

Insecticides Moderately Toxic to Bees

These materials can be used with limited damage to bees if not applied over bees in the field or at the hives. Correct dosage, timing, and method of application are essential. This group includes:

biothion (Abate)
carbophenothion (Trithion)
Carzol
coumaphos (Co-Ral)
DDT
demeton (Systox)
Dimetilan
disulfotan (Di-Syston)
endosulfan (Thiodan)
endothion
endrin
Galecron (Fundal)
methyl demeton (Meta Systox)
mirex
oxydemetonmethyl (Meta Systox R)
Perthane
phorate (Thimet)
phosalone (Zolone)
Pyramat
ronnel
tartar emetic

Insecticides Relatively Nontoxic to Bees

Materials in this group can be used around bees with few precautions and a minimum of injury to bees. This group includes:

Relatively Nontoxic Insecticides

Acarol
allethrin
Aramite
Bacillus thuringiensis
binapacryl (Morocide)
Bordeaux mixture
chlorbenside (Mitox)
chlorobenzilate
chloropropylate
dicofol (Kelthane)
Dilan
Dimite (DMC)
dioxathion (Delnav)
ethion (Nialate)
fenson (Murvesco)
Kepone
Lethane
Lovozal
methoxychlor
Morestan
nicotine
Omite
oil sprays (superior type)
ovex
Pentac
Plictran
Pyrethrum
rotenone
sabddilla
Strobane
Sulphenone
TDE (Rhothane)
tetradifon (Tedion)
toxaphene
trichlorfon (Dylox, Dipterex)

*Relatively Nontoxic Fungicides**

bordeaux mixture
captan
copper oxychloride sulfate
copper 8-quinolinolate
copper sulfate
copper oxide
Dexon
folcid (Difolatan)
folpet (Phaltan)
glyodin (Glyoxide)
maneb (Manzate)
Mylone
nabam (Parzate)
Polyram

*Most fungicides, herbicides, and defoliants are relatively nontoxic.

Relatively Nontoxic Fungicides (cont.)

dichlone (Phygon)	sulfur
dinocap (Karathane)	thiram (Arasan)
dodine (Cyprex)	zineb (Parzate)
Dyrene	ziram (Zerlate)
ferbam (Fermate)	

Relatively Nontoxic Herbicides

amitrole	MCPA
CDAA (Randox)	monuron
CDEC (Vegedex)	NPA
dalapon	paraquat
dicamba (Banvel-D)	Planavin
diquat	sesone
diuron (Karmaex)	simazine
EPTC (Eptam)	2,3,6-TBA (Trysben)
EXD (Herbisan)	2,4-D
IPC	2,4,5-T

Relatively Nontoxic Defoliants

DEF	PREP
merphos (Folex)	

Some Additional Points to Remember

1. Prevention of bee losses is the joint responsibility of the spray operator, the farmer, and the beekeeper. Before spraying is done, the beekeeper should be notified in ample time to allow him to arrange to protect or move his colonies.

2. Sprays generally are less hazardous to bees than are dusts.

3. Late evening and early morning spray treatments (after 9 p.m. DST and before dawn, 3 a.m.) will generally reduce bee deaths. However, applications to corn are safer to bees when made between noon and midnight, *not* early in the morning.

4. Aircraft applications of technical/low volume malathion are HIGHLY poisonous to bees and should be used chiefly on rangelands for grasshopper control.

5. Ground sprayer treatments usually are less severe on bees than are aircraft applications.

6. Spraying or dusting while bees are active in the fields will increase bee kills.

7. Treatment over hives when bees are clustered outside the hive during hot weather increases bee deaths.

8. Drift to neighboring fields in blossom, or to adjacent blossoming weeds and wild flowers, may result in substantial bee poisoning.

9. Bees located in or very near fields before pesticide treatment may sustain serious death losses. Bees moved into fields and orchards after spraying is completed may suffer little loss.

10. To eliminate pests without endangering the bees, use the recommended amount of a pesticide that is least toxic to the bees but potent enough to kill pests.

11. Bees fly most actively at temperatures above 55° F. Spraying when temperatures stay below 55° will do little harm to bees.

12. Insecticides cause heavy bee losses when applied to orchards when trees are not in bloom but when there is attractive clover beneath them, and to alfalfa when weeds, such as yellow rocket and mustard, are in bloom.

Poison Resource Centers

The Poison Resource Centers listed below have been established to provide information about the treatment of poisoning cases. Anyone with a poisoning emergency can call the toll-free telephone number for help. Personnel at the Resource Center will give you first-aid information and direct you to local treatment centers if necessary.

<u>Chicago and Northeast Illinois</u>

1753 West Congress Parkway
Chicago, Illinois 60612
Telephone: 800-942-5969

<u>Northern and Central Illinois</u>

530 N.E. Glen Oak
Peoria, Illinois 61603
Telephone: 800-322-5330

<u>Central and Southern Illinois</u>

800 East Carpenter
Springfield, Illinois 62702
Telephone: 800-252-2022

CONVERSIONS

Fluid

1/6 fluid ounce (oz) = 1 teaspoon (tsp)
1/2 fluid ounce = 1 tablespoon (tbs) = 3 teaspoons
1 fluid ounce = 2 tablespoons = 1/8 cup
8 fluid ounces = 1 cup = 1/2 pint (pt)
16 fluid ounces = 2 cups = 1 pint
32 fluid ounces = 4 cups = 1 quart (qt)
128 fluid ounces = 16 cups = 1 gallon (gal)

Linear

1 inch = 2 1/2 centimeters (cm) = 25 1/2 millimeters (mm)
1 foot (ft) = 12 inches (in)
1 yard (yd) = 3 feet
1 rod = 5 1/2 yards = 16 1/2 feet
1 mile = 320 rods = 1,760 yards = 5,280 feet

Area

144 square inches = 1 square foot
9 square feet = 1 square yard
30 1/4 square yards = 1 square rod
= 272 1/4 square feet
43,560 square feet = 1 acre
4,840 square yards = 1 acre
160 square rods = 1 acre
640 acres = 1 square mile

Weight

1 ounce = 28 1/3 grams (g)
1 pound (lb) = 16 ounces = 453 1/2 grams
2 1/5 pounds = 1 kilogram (kg) = 1,000 grams
1 ton = 2,000 pounds = 907 kilograms

DILUTION TABLES

Amount of Liquid Pesticide Product Required to Obtain Recommended Rate

Concentration of liquid formulation	Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water				
	¼ lb	½ lb	1 lb	2 lb	3 lb
			Amount of pesticide product required		
1 lb/gal	1 qt	2 qt	1 gal	2 gal	3 gal
1½ lb/gal	1⅓ pt	1⅓ qt or 2⅔ pt	5⅓ pt	5⅓ qt	2 gal
2 lb/gal	1 pt	1 qt	2 qt	1 gal	6 qt
4 lb/gal	8 oz	1 pt	1 qt	2 qt	3 qt
6 lb/gal	6 oz	10 oz	1⅓ pt	1⅓ qt	2 qt
8 lb/gal	4 oz	8 oz	1 pt	1 qt	3 pt

Amount of Dry Pesticide Product Required to Obtain Recommended Rate

Concentration of dry formulation	Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water				
	¼ lb	½ lb	1 lb	2 lb	3 lb
			Amount of pesticide product required		
15%	1⅔ lb	3⅓ lb	6½ lb	13 lb	20 lb
25%	1 lb	2 lb	4 lb	8 lb	12 lb
40%	10 oz	1¼ lb	2½ lb	5 lb	7½ lb
50%	8 oz	1 lb	2 lb	4 lb	6 lb
65%	6 oz	12 oz	1½ lb	3 lb	4½ lb
75%	5⅓ oz	11 oz	1⅓ lb	2⅔ lb	4 lb
80%	5 oz	10 oz	1¼ lb	2½ lb	3¾ lb

BEFORE USING ANY PESTICIDE

STOP

READ THE LABEL